Appendix 13b:

ODI RoRE risk analysis: a report for Yorkshire Water

YorkshireWater

Economic Insight

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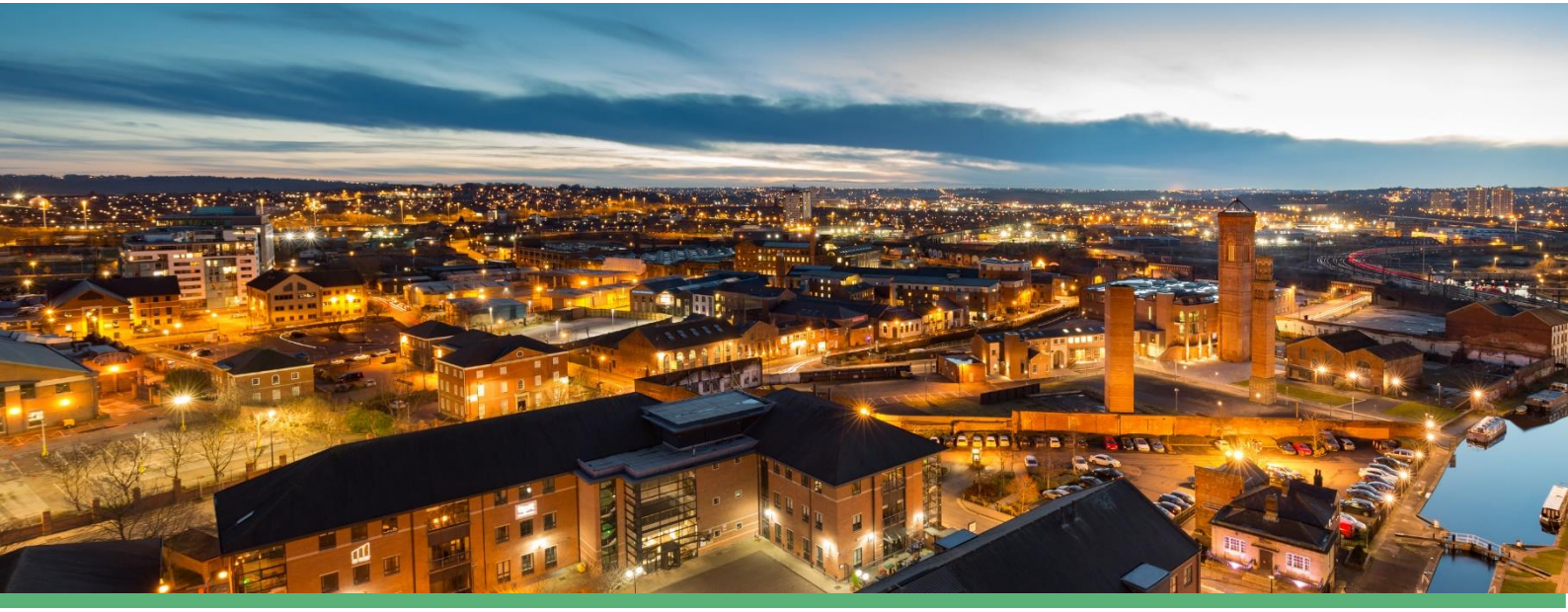
Economic Insight Ltd

ODI RoRE RISK ANALYSIS

A report for Yorkshire Water

CONTENTS



1. Executive Summary

This report sets out a detailed assessment of the ODI related RoRE risk faced by Yorkshire Water at PR19. The scope of our work has included developing a framework for evaluating risk, then developing analysis and evidence to apply the framework in practice. Our work is centred around a Monte Carlo risk model, which draws on both historical data - and expert views - to provide a comprehensive risk analysis. Importantly, the model itself has been used to support close collaborative working with Yorkshire, whereby the final calibration of risk (and ODI package design) has been arrived at iteratively. Key themes and findings arising from our work include: (i) the ODI RoRE range for Yorkshire is between -2.11% and +1.92% at PR19 – this is consistent with Ofwat's guidelines; (ii) the distribution of ODI risk is modestly skewed to the downside – this is both consistent with economic theory and with the company having an ambitious Plan; (iii) the approach and model functionality are fully consistent with Ofwat's method – and take into account issues such as the non-independence of risk; and the company's ability to mitigate risk. Our work has also identified various recommendations for Yorkshire, including embedding risk analysis as part of business as usual.

1.1 Background and scope of work

At PR19, companies are required to submit return on regulatory equity (RoRE) risk analysis to support their Business Plans. The main purpose of this is to ensure that there is robust evidence relating to the 'risk' associated with the delivery of plans. Within this requirement, Ofwat has further stipulated a range of specific 'risk scenarios' that companies must submit evidence on (where, for each, high and low case financial impacts must be evaluated). One of these scenarios relates to the RoRE risk exposure associated with ODIs.

Accordingly, Yorkshire asked us to provide an assessment of its ODI related RoRE risk. Here, **our overarching objective was to both develop and implement a methodology for evaluating ODI RoRE risk.** In doing so, further aims included:

YORKSHIRE ASKED US TO DEVELOP AND APPLY A METHOD FOR ASSESSING ODI RoRE RISK. IMPORTANTLY, THE SCOPE OF OUR WORK INCLUDED ADVISING ON RISK CALIBRATION - AND HELPING THE COMPANY TO REFINE ITS ODI PACKAGE.

- Ensuring that the analysis and approach was highly robust, so that the company had an **evidence base of the highest possible quality.**
- Ensuring that the approach was **consistent with Ofwat's methodology** requirements (e.g. the high / low cases should reflect P10/P90 values, the analysis should assume notional gearing etc).
- Of specific importance to ODIs, ensuring that any approach properly **reflects that being at the 'extremes' of outcomes on multiple ODIs simultaneously is 'unlikely'.** As such, overall ODI risk cannot not considered independently across individual ODIs and calculated 'additively'.
- Provide a valuable business tool for Yorkshire that can be used, not only to analyse risk, but also to **help refine and calibrate the overall ODI risk package,** taking into account the company's broader calibration of risk across all elements of its Plan (e.g. totex etc).

Consistent with the above, the scope of our work included:

- Developing an overall framework for evaluating the RoRE risk impacts of ODIs.
- Developing the analytical tools and models necessary to implement the approach in practice.
- Advising on the calibration of risk and refinement of the company's ODIs by 'running' the relevant models iteratively, to help the company understand the implied risk exposure.
- Advising on the underlying performance risk of ODIs.
- Developing the RoRE risk outputs required to populate data table *App26,* relating to ODIs.

1.2 Our method and approach

1.1 Framework and ORRSM model

Our method started from developing a clear analytical framework within which to analyse ODI RoRE risk. Our framework brings together underlying performance risk and incentive rates, in order to arrive at estimated financial impacts (risks).

To apply our framework in practice, we developed the 'ODI RoRE Risk and Scenario Model' (ORRSM). The model calculates the financial impact arising from differences between outturn ODI performance and performance commitment (PC) levels. The model can be used in two main ways:

- **Scenario (expert) mode** – in which the user can specify a level of outturn performance to understand the implications of this.
- **Monte Carlo mode** – under which the ORRSM calculates a large number of 'possible' financial impacts by randomly drawing outturn performance levels based on probability distributions that are assigned at the individual ODI level. The model then calculates the P10 and P90 values across the full range of

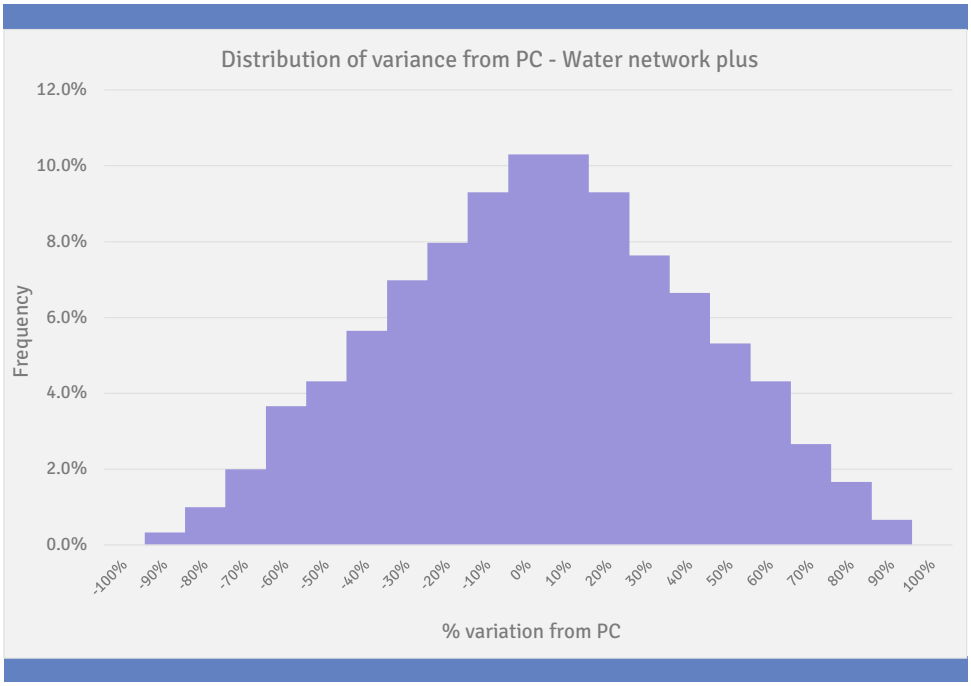
A SOPHISTICATED MONTE CARLO RISK MODELLING TOOL, DEVELOPED BESPOKE FOR YORKSHIRE, IS AT THE HEART OF OUR APPROACH.

randomly drawn outcomes (i.e. reflects risk at the appointee level, as per Ofwat's requirements). The purpose of this functionality, therefore, is to provide a comprehensive and robust risk analysis, which can also be used in the population of data table *App26.* Importantly, of course, **this functionality takes account of the fact that it is unlikely that a company will simultaneously experience outcomes performance at the 'extremes' of distributions across all its PCs.**

The model utilises the best available data. In particular, key inputs required are probability distributions to reflect the underlying performance risk of Yorkshire's ODIs. To estimate these, we utilised both historical data and expert views from within the company. In relation to the former, we used published performance data on PR14 ODIs to calculate the *percentage differences* between PC levels and outturn performance. We then used this to derive probability distributions.

By specifying the distributions in terms of *percentage* variations from the PC, we were able to: (i) pool observations across companies – which not only increases the number of data points used to estimate distributions, but also is likely to better reflect underlying performance risk; (ii) use the same distribution for multiple ODIs (where appropriate) – as by applying percentages, we still preserve differences in ODI 'levels' and preserve differences in the extent of financial risk (which is driven by differences in incentive rates and other ODI parameters, such as deadbands etc). We explored various ways of estimating distributions, including both triangular and normal – and further created 'high' and 'low' risk variants for each. Ultimately, in our modelling we elected to make use of triangular distributions, which are commonly used in Monte Carlo analyses. Full details of our estimated distributions are set out subsequently – the figure below provides *one* example, for water network plus related ODIs.

Figure 1: Water network plus – base case triangular distribution



Source: Economic Insight

'The choice of probability distributions also took into account Yorkshire's ability to manage and mitigate risk, which is consistent with Ofwat's methodology.'

Within our modelling, underlying probability distributions are attached to ODIs at an individual level, and Yorkshire led in selecting the 'most appropriate' distributions (given their own business knowledge). Importantly, and as we explain in the main body of this report, the choice of probability distributions also took into account Yorkshire's ability to manage and mitigate risk, which is consistent with Ofwat's methodology.

1.2 Risk calibration and ODI package refinement

As previously set out, the scope of our work was not simply to provide Yorkshire with 'results'. Rather, we have advised the company on risk calibration and have worked closely with them in an iterative way to help refine the final package of ODIs. Consistent with this, the ORRSM was not just used to populate Plan data tables; rather, it was used as a 'tool' to help the company arrive at a coherent and well-calibrated set of proposals.

Specifically, our model includes a wide range of flexibility that allows the user to adjust and refine all of the key parameters of ODIs. Given this, during our work for Yorkshire at various times we ran 'draft' ODI packages through the model, and then carefully analysed the implied risk exposure. Where the results indicated that the risk calibration might not be appropriate (e.g. because the RoRE range was felt to be 'too wide', or because certain bill impacts might be undesirable) the model was then used to: (i) better understand 'why' this was the case; and then (ii) identify areas where the ODI package should be refined. As such, a high degree of confidence can be attached to the ODI package risk calibration.

1.3 Assurance

The ORRSM has been through a robust quality assurance process. This included:

- Developing a model development plan prior to work beginning.
- Keeping a log of all model changes.
- Full internal audits during model development.
- A detailed full internal audit of the finalised model.
- Challenge and review by Yorkshire (i.e. various versions of the model were shared with Yorkshire during development, allowing the company to review and request changes, where required).

The above steps are in addition to Yorkshire's own broader audit and assurance processes, to which our work was also subject.

1.4 Key ODI RoRE risk results

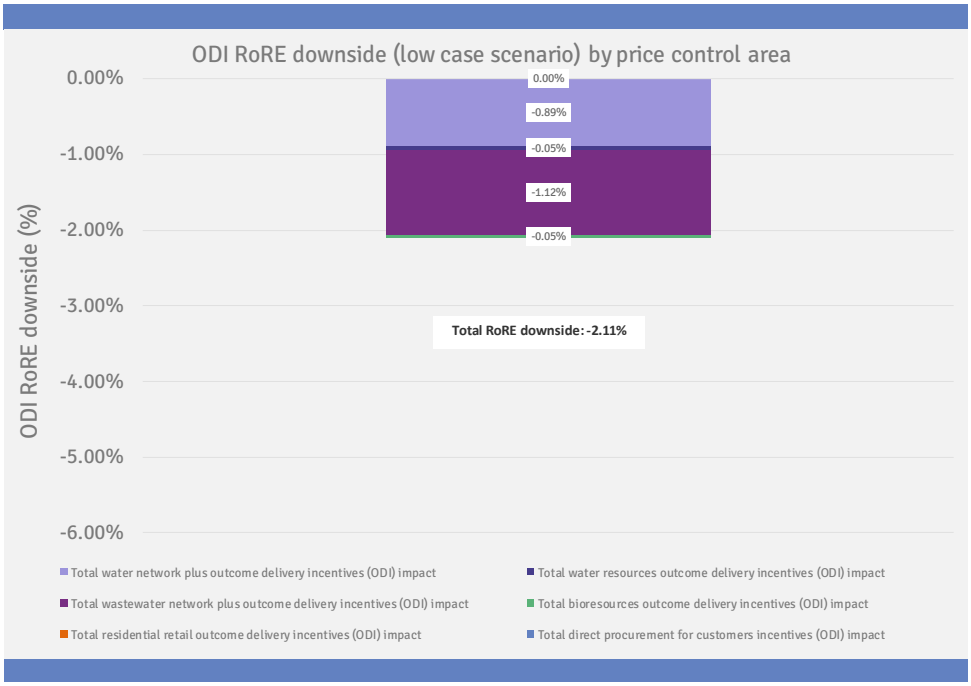
'Our Monte Carlo RoRE risk modelling suggests that the RoRE range associated with Yorkshire's PR19 ODI package is -2.11% to +1.92%.

In summary, our Monte Carlo RoRE risk modelling suggests that the RoRE range associated with Yorkshire's PR19 ODI package is -2.11% to +1.92%. The following figures provide a graphical summary of the split of the overall range by price control area, in a 'stacked column' format, as typically utilised by Ofwat.

Figure 2: ODI RoRE range impact - upside

Source: Economic Insight

Figure 3: ODI RoRE range impact - downside

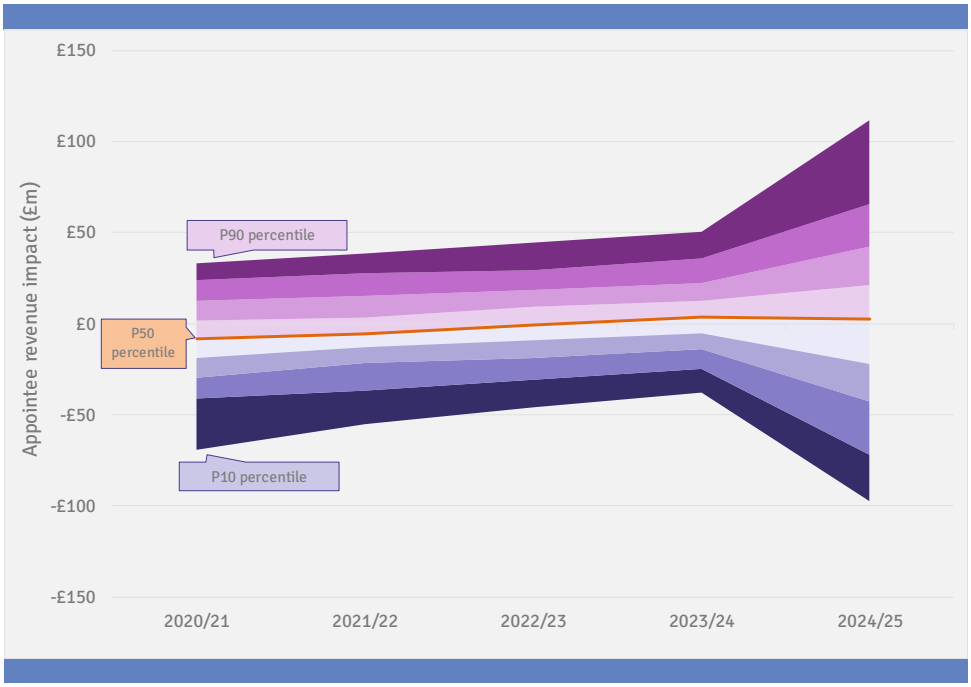


Source: Economic Insight

The following fan chart shows the potential spread of appointee level revenue impacts over time, based on our Monte Carlo analysis. Reflecting the slight skew to the downside, the P50 line for revenue impact is slightly negative. Whilst the vast majority of the company's ODIs are 'in-period', Yorkshire's package also includes a limited number of 'end-of-period' ODIs. This explains why the spread of impacts widens in the final year. End-of-period ODIs included in Yorkshire's package are:

- working with others;
- land conserved and enhanced;
- length of river improved; and
- carbon.

Figure 4: Probability fan chart of appointee level revenue impacts



Source: Economic Insight

1.5 Conclusions and recommendations

The key conclusions arising from our work for Yorkshire are as follows:

- **Overall, we consider that the totality of evidence and analysis presented in this report provides Yorkshire with a robust, comprehensive and objective, assessment of ODI risk at PR19.**

- It is fundamentally challenging to measure underlying performance risk for ODIs – primarily because of their relative recentness. Given this, we think that **approaches which blend both 'data' and 'expertise' (such as that deployed here for Yorkshire) are preferable at PR19.**

- **The implied ODI range of -2.11% to +1.92% is within Ofwat's guideline ODI range for PR19 (which is +/- 1% to 3%).** This provides further assurance as to the likely reasonableness of the risk exposure associated with the company's ODI package.

- **The company's ODI risk is moderately skewed to the downside.** In our view, this is consistent with both economic theory – and with the company's Plan being 'ambitious'.

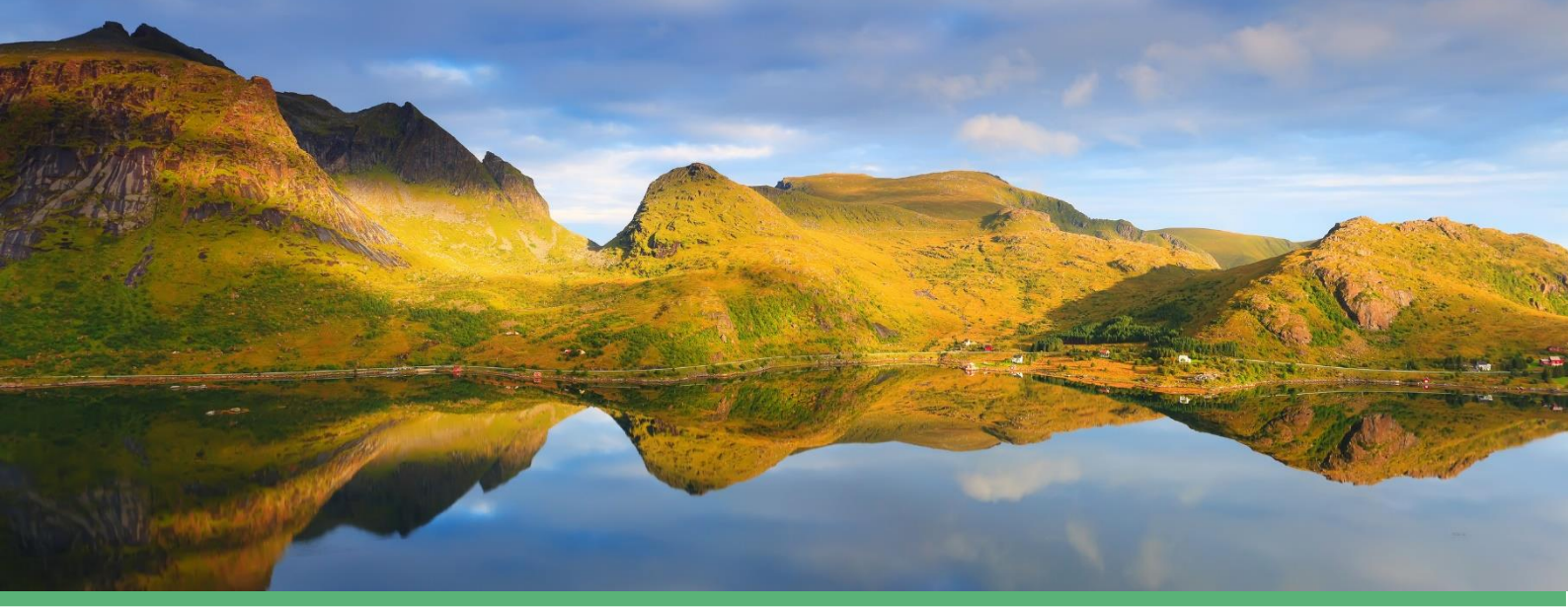
- **The company has taken a holistic approach to risk calibration, taking into account risk exposure across other areas of its Plan.**

Following from the above, we have three recommendations:

- **Having developed this approach to risk analysis, Yorkshire should seek to embed it as part of 'business as usual' going forward.**

- **Yorkshire should monitor and evaluate the effectiveness of its risk-mitigation strategies.**

- **Where practical, Yorkshire should develop a framework, and analytical evidence, to better understand the drivers of key areas of outcome performance.**



2. Introduction and context

At PR19 companies need to provide robust evidence regarding their Plan delivery risk, including a number of RoRE risk scenarios specified by Ofwat – one of which relates to ODIs. Accordingly, Yorkshire Water commissioned Economic Insight to develop and implement an overall approach and methodology to assessing the RoRE risk associated with its package of ODIs. In addressing Yorkshire's requirements, we have further sought to ensure that our approach is consistent with Ofwat's methodology. We also consider it important that any risk analysis properly reflects the fact that being at the 'extremes' of outcomes across multiple ODIs simultaneously is unlikely. In addition, rather than simply provide Yorkshire with a 'black box' or 'off the shelf' answers, our work has also included developing an approach that allows the company to use our modelling to support the refinement of its ODI package as it finalises its PR19 Plan.

2.1 Background context

At PR19, companies are required to submit RoRE risk analysis to support their Business Plans. The main purpose of this is to ensure that there is robust evidence relating to the 'risk' associated with the delivery of plans. Within this requirement, Ofwat has further stipulated a range of specific 'risk scenarios' that companies must submit evidence on (where, for each, high and low case financial impacts must be evaluated). One of these scenarios relates to the RoRE risk exposure associated with ODIs.

For each scenario (i.e. including in relation to ODIs) Ofwat has stated that: *"the scenarios should be designed to represent realistic high and low cases. The scenarios are not intended to reflect extreme possibilities. We proposed that we would expect these to be specified at the P10/P90 range of probabilities. This means there would be a 20 percent chance of the key risk factor(s) falling outside of the P10 (high case) and P90 (low case) assumptions used for the scenario."*[1]

[1] *'Delivering Water 2020: Our final methodology for the 2019 price review. Appendix 12: Aligning risk and return.' Ofwat (2018); page 11.*

Ofwat's Final Methodology also states:

- That all analysis should be based on the notional company structure.
- That companies should provide commentary and evidence to support their submitted scenario impacts (sufficient to understand how the upside and downside impacts have been derived).

Companies must also provide data on their 'high' and 'low' case financial impacts as part of their plans. Specifically, within data table *App26*, companies must submit the £m value associated with the high and low case impacts, relative to a 'base case' (assumed to be the values in their plans). Ofwat's guidance on the *App26* table provides further information as to the nature of analysis and evidence that companies should develop – as follows:

- *"In assessing the effects, companies should consider the full range of financial impacts for each scenario. This includes any direct impacts, but also take account of any efficient management responses to the relevant change in business conditions.*
- *Companies should also explain their assumptions on how incentives are calibrated and make clear any assumptions regarding outperformance or underperformance.*
- *For ODIs the P10 and P90 values in blocks I & J of table App26 are for the overall P10 and P90 values for outcomes at the appointee level. For example, the P10 values for the high RoRE case should reflect the scenario in which ODI outperformance payments for the appointee would equal or exceed these values 10% of the time. So while the data is split between the price controls, the probability is defined at the appointee level. Note that since the probability is defined at the appointee level, for the P10 (high case) and P90 (low case) for ODI performance, it is likely not appropriate to arrive at these figures by simply summing the values for each individual ODI in table App1.*
- *Performance against each individual ODI will be driven by different factors, therefore, the P10 and P90 values for each ODI cannot all be assumed to occur together and some statistical analysis of all ODIs should therefore be undertaken. This could for example involve Monte Carlo analysis using both variances for individual ODIs and covariance's between ODIs."*[2]

'RoRE analysis will be an important component of our initial assessment of business plans.' - Ofwat

Ofwat has also signalled the importance of companies having robust evidence on risk as part of their PR19 Plans, highlighting that: *"the RoRE analysis will be an important component of our initial assessment of business plans."*[3] Accordingly, Ofwat's Initial Assessment of Plans (IAP) includes a specific test relating to risk analysis – as follows: "*To what extent has the company demonstrated a clear understanding and assessment of the potential risks in its RoRE assessment, including the effect of the risk management measures it will have in place, across each of the price controls?"* [4]

Relating to the above, Ofwat's IAP guidance indicates that, in addressing this test, high quality plans will *"demonstrate they have a clear understanding of the risks that could*

[2] *'Delivering Water 2020: Our methodology for the 2019 price review Final guidance on business plan data tables.' Ofwat; page 28*

[3] *'Delivering Water 2020: Our methodology for the 2019 price review Appendix 13: Initial assessment of business plans.' Ofwat (2018); page 170*

[4] *'Delivering Water 2020: Our methodology for the 2019 price review Appendix 13: Initial assessment of business plans.' Ofwat (2018); page 20.*

affect delivery of the plan, including through RoRE scenario analysis, and that they have appropriate risk management practices in place."[5]

2.2 Objectives and scope of our work

2.2.1 Aims and objectives

IT IS IMPORTANT THAT ANY ANALYSIS OF ODI RoRE RISK REFLECTS THE FACT THAT BEING AT THE 'EXTREMES' OF OUTCOMES ON MULTIPLE ODIs SIMULTANEOUSLY IS 'UNLIKELY.'

Following from the above, Yorkshire asked us to provide an assessment of its ODI related RoRE risk. Here, **the overarching objective of our work was to both develop and implement a methodology for evaluating ODI RoRE risk.** In doing so, further aims included:

- Ensuring that the analysis and approach was highly robust, so that the company had an **evidence base of the highest possible quality.**
- Ensuring that the approach was **consistent with Ofwat's final methodology** requirements (e.g. the high / low cases should reflect P10/P90 values, the analysis should assume notional gearing etc).
- Of specific importance to ODIs, ensuring that any approach properly **reflects that being at the 'extremes' of outcomes on multiple ODIs simultaneously is 'unlikely'.** As such, overall ODI risk cannot not considered independently across individual ODIs and calculated 'additively'.
- Provide a valuable business tool for Yorkshire that can be used, not only to analyse risk, but also to **help refine and calibrate the overall ODI risk package,** taking into account the company's broader calibration of risk across all elements of its Plan (e.g. totex etc).

2.2.2 Scope of work

Consistent with the above, the scope of our work included:

- Developing an overall framework for evaluating RoRE risk impacts of ODIs.
- Developing the analytical tools and models necessary to implement the approach in practice.
- Advising on the calibration of risk; and the refinement of the company's ODIs, by 'running' analysis iteratively, to help the company understand the implied risk exposure.
- Advising on the underlying performance risk of ODIs.
- Developing the RoRE risk outputs required to populate data table *App26* relating to ODIs.

[5] *'Delivering Water 2020: Our methodology for the 2019 price review Appendix 13: Initial assessment of business plans.' Ofwat (2018); page 20.*

3. Method and approach

Our approach began by developing an overarching framework, which brings together the combination of outcome performance risk and incentive rates, in order to calculate ODI related financial risk. To implement our approach in practice, we developed the 'ODI RoRE Risk and Scenario Model', which can be used to both assess the financial impact of specific scenarios, or (using a Monte Carlo simulation) calculate a range of potential impacts, based on underlying probability distributions. In addition to being used for the purpose of 'risk analysis', the modelling tool provides a robust basis for helping Yorkshire 'refine' its ODIs and calibrate its overall risk / reward package. This chapter expands on our approach, addressing: (i) our framework; and (ii) the ODI RoRE risk model itself – where in turn we describe: the model structure; model functionality; key input data sources; model outputs; and our quality assurance processes.

3.1 Framework

Our starting point for our work for Yorkshire was to develop an overarching framework for evaluating ODI related risk. Accordingly, our framework was as follows:

$$Financial\ risk = Performance\ risk * incentive\ rates$$

Where:

- *Financial risk* is the £m impact of the risk scenario, relative to the base case.
- *Performance risk* refers to the risk that outturn performance deviates from the PC level.
- *Incentive rates* is the '£ per unit' rate used to calculate out and underperformance payments.[6]

[6] *In addition, other parameters that affect financial payments, such as caps, collars and deadbands (if applicable) are also taken into account.*

3.3 ODI RoRE Risk and Scenario Model (ORRSM)

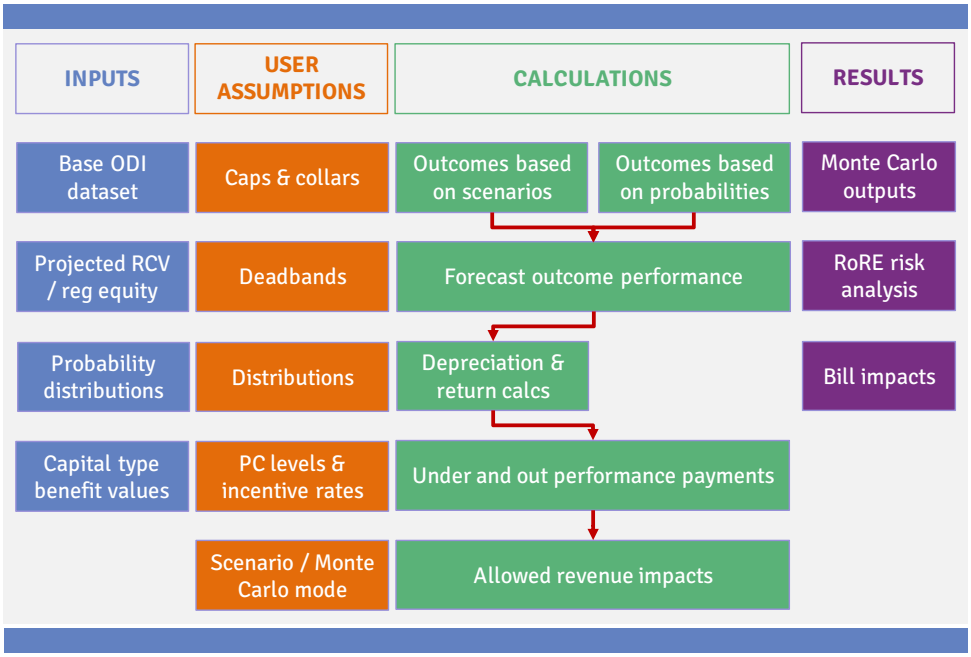
To apply our framework in practice, we developed the ORRSM. The following subsections provide further details of the model structure and functionality.

3.3.1 Overview of model structure

The primary purpose of the ORRSM is to calculate the £m financial impact associated with an 'outturn' level of ODI performance, relative to the performance level assumed in the PC (and so, in turn, assist Yorkshire in finalising the calibration of its ODIs).

Given this, the ORRSM is primarily structured around a set of inputs (the most material of which relate to detailed information regarding the 'base' set of ODIs proposed by the company) and a set of calculations that drive the ultimate revenue impact arising from an assumed level of actual performance (where the calculations are implemented such as to replicate Ofwat's final methodology for PR19). The structure of the model is summarised in the following figure.

Figure 5: Model schematic



Source: Economic Insight

3.3.2 Model functionality

Within the above structure, the ORRSM can be used in two distinct 'modes' – as follows:

- **Scenario (expert) mode.** In this mode, the model calculates financial impacts based on the differences between the base PC levels (as per the input data) and an 'assumed' forecast level of performance, as specified by the user. The main purpose of this is to allow the user to quickly review the financial implications of a potential service outcome of interest. This functionality does not, however, provide any basis for determining *'how likely'* that service outcome is – nor, therefore, of the probability of the end impact.

A KEY FEATURE OF THE ORRSM IS ITS 'MONTE CARLO' MODE, WHICH ALLOWS ONE TO ITERATE THROUGH A LARGE NUMBER OF POTENTIAL FINANCIAL IMPACTS TO BETTER UNDERSTAND OVERALL ODI RISK EXPOSURE.

- **Monte Carlo mode.** In this mode, the ORRSM calculates a large number of 'possible' financial impacts by randomly drawing outturn performance levels based on probability distributions that are assigned at the individual ODI level. The model then calculates the P10 and P90 values across the full range of randomly drawn outcomes *at the appointee level* (consistent with Ofwat's method, which requires that the high / low risk scenarios *for App26* are defined at the appointee level). The purpose of this functionality, therefore, is to provide a robust risk analysis that can be used in the population of data table *App26.* Importantly, of course, this functionality takes account of the fact that it is unlikely that a company will simultaneously experience outcomes performance at the 'extremes' of distributions across all of its PCs. Consequently, we consider this to be a much more robust approach to risk analysis than simply 'summing' probabilities associated with individual PCs (which would incorrectly assume independence of outcomes).

In the following sub-sections, we provide further details of the model's core functionality.

3.3.2.1 User assumptions to refine ODI design

Because the ORRSM is also intended to help Yorkshire refine and calibrate its final package of ODIs, the user interface sheets of the model allow one to overlay detailed assumptions regarding the full set of ODI parameters (at the individual ODI level). This includes being able to flex:

- underlying PC levels;
- incentive rates;
- thresholds for enhanced incentive rates (where applicable); and
- deadbands, caps and collars.

The following figures contain screenshots, illustrating some of the above flexibility.

Figure 6: Flexing incentive rates (illustrative figures only)

User Interface - PC Incentive rates

This sheet allows the user to specify incentive out and underperformance rates, by ODI

Choose whether to apply base data incentive rates, or user specified

Apply base incentive rates
Apply user specified incentive rates

Current selection:
Apply base incentive rates

ODI info				Base data incentive rates		User specified incentive rate	
ODI number	ODI name	Performance metric	Units	Outperformance payment rate (£m per unit of performance)	Underperformance payment rate (£m per unit of performance)	Outperformance payment rate (£m per unit of performance)	Underperformance payment rate (£m per unit of performance)
1	C-Mex	Score based on Customer Expierence Measure	Score based on Customer Expierence Measure				
4	Land conserved and enhanced	The area of land conserved and enhanced in the Yorkshire Water region through land management and biodiversity focussed projects	Ha of Land	£0.00	£0.00		
6	Length of river improved	The number of kilometres of river improved in the Yorkshire Water region	Km of River	£0.18	£0.18		

Source: Economic Insight

Figure 7: Flexing deadbands (illustrative only)

User Interface - deadbands

This sheet allows the user to specify deadbands for individual ODIs (Ofwat default is for no deadbands to apply)

Choose whether to specify deadbands or apply those in the draft App1 tab.

Apply deadbands from draft App1
Apply deadbands entered below

Current selection
Apply deadbands from draft App1

If you choose to enter your own deadbands, specify the percentage in the yellow cells below.

			Outperformance deadband size						
ODI number	ODI name	User specified deadband (% of PC)	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27
1	C-Mex								
2	D-Mex								
3	Working with others		0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	Land conserved and enhanced		0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	Integrated catchment management		0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	Length of river improved		0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	Biosecurity implementation		0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: Economic Insight

Figure 8: Flexing PC levels (illustrative only)

User Interface - Performance Commitment levels

This sheet allows the user to specify scenarios that vary the PC level (i.e. "target performance") by individual ODI

1. Choose whether to apply 'base' PC levels, as per 'Base ODI set' tab, or run a scenario using user specified PC levels, as below

Apply base PC levels
Apply scale % factor to base PCs
Apply user specified PC levels

Current selection
Apply base PC levels

User specified % scale factors to PCs - adjusted based PCs by a % (only applies if selected above)

ODI number	ODI name	Performance metric	Units	% Adjustment factor	Direction of improvement	Application of factor
1	C-Mex	Score based on Customer Expierence Measure	Score based on Customer Expierence Measure	5.0%	Up	5.0%
2	D-Mex	Score based on Developer Services Measure	Score based on Developer Services Measure	5.0%	Up	5.0%
3	Working with others	The number of projects we deliver in partnership with independent agencies, organisations or individuals.	Number of Solutions	5.0%	Up	5.0%
4	Land conserved and enhanced	The area of land conserved and enhanced in the Yorkshire Water region through land management and biodiversity focussed projects and investments on our	Ha of Land	5.0%	Up	5.0%
5	Integrated catchment management	The percentage of catchments in which Yorkshire Water operates, where, working with stakeholders, we implement the Natural Capital Operator	% of catchments	5.0%	Up	5.0%

Source: Economic Insight

Note, the above user interface tabs effectively allow the user to 'overwrite' or 'flex' base case assumptions. For example, the 'base' ODI information is primarily drawn from App1 data, where all ODI parameters (such as PCs, deadbands, etc) are specified.

By providing the above flexibility, the model allows the user to undertake risk analysis and review the implied RoRE ranges in the wider context of the company's PR19 Plan. Having done this, if there is a concern that the implied RoRE range might not be appropriate (i.e. the calibration of risk is not acceptable to customers / investors etc) then the model can be used to refine the ODI parameters as above, then 're-run' the risk analysis, until the overall calibration is deemed to be acceptable. Put simply, the model can itself be used as an input into finalising ODI proposals.

3.3.2.2 The Monte Carlo functionality

As explained previously in the discussion of 'model structure', the ORRSM includes input information on probability distributions – as illustrated in the following figure (further information on the sources used to derive the distributions is set out subsequently).

Figure 9: Probaiblity distribution inputs

Probability distributions

This tab contains probability distributions for the variance between outturn and the PC by price control area

	Water resources			Water network plus		
Probability (out of 100)	Water resources (low risk)	Water resources (base)	Water resources (high risk)	Water network plus (low risk)	Water network plus (base)	Water network plus (high risk)
0.0000001	-0.503764724	-0.719663891	-0.935563058	-0.656162521	-0.93737503	-1.218587539
0.0033331	-0.461046096	-0.65863728	-0.856228463	-0.603672765	-0.862389664	-1.121106563
0.0066661	-0.443254462	-0.633220659	-0.823186857	-0.58181161	-0.831159443	-1.080507275
0.0099991	-0.429602399	-0.613717713	-0.797833027	-0.56503688	-0.807195543	-1.049354207
0.0133321	-0.418093158	-0.59727594	-0.776458722	-0.550895104	-0.786993006	-1.023090908
0.0166651	-0.407953303	-0.582790432	-0.757627562	-0.538435937	-0.769194195	-0.999952454
0.0199981	-0.398786167	-0.569694525	-0.740602882	-0.527171982	-0.753102831	-0.97903368
0.0233311	-0.390356113	-0.557651589	-0.724947066	-0.516813702	-0.738305288	-0.959796874
0.0266641	-0.382509607	-0.546442295	-0.710374984	-0.507172446	-0.724532066	-0.941891686
0.0299971	-0.375140005	-0.535914293	-0.696688581	-0.49811718	-0.711595971	-0.925074762
0.0333301	-0.368169662	-0.52595666	-0.683743658	-0.489552494	-0.699360705	-0.909168917
0.0366631	-0.361539959	-0.516485656	-0.671431352	-0.481406364	-0.687723377	-0.89404039
0.0399961	-0.355205357	-0.507436224	-0.659667091	-0.473622834	-0.676604048	-0.879585262
0.0433291	-0.34912964	-0.498756629	-0.648383617	-0.466157404	-0.665939149	-0.865720894
0.0466621	-0.343283445	-0.490404922	-0.637526398	-0.458973996	-0.655677138	-0.852380279
0.0499951	-0.337642573	-0.482346533	-0.627050493	-0.452042875	-0.645775535	-0.839508196
0.0533281	-0.332186799	-0.47455257	-0.616918341	-0.445339189	-0.636198841	-0.827058494
0.0566611	-0.326899016	-0.466998594	-0.607098172	-0.438841919	-0.626917028	-0.814992136
0.0599941	-0.3217646	-0.459663714	-0.597562828	-0.432533096	-0.617904423	-0.803275751

Source: Economic Insight

'A user interface sheet 'assigns' a distribution to each ODI individually.'

A user interface sheet 'assigns' a distribution to each ODI individually (see following figure) The distributions are, by default, defined in terms of a *percentage deviation from a base case PC level* – which in turn allows the user to assign the same distribution to more than one ODI, should this be considered appropriate.

Figure 10: Probaiblity distribution inputs

User Interface - probability distributions

This sheet allows the user to specify which probability distributions to apply by ODI (used for RoRE risk analysis).
Change the cells highlighted in yellow and then press 'Run Monte Carlo'.

ODI number	ODI name	Select probability distribution to apply
1	C-Mex	C-MeX
2	D-Mex	D-MeX
3	Working with others	Appointee (high risk)
4	Land conserved and enhanced	Appointee (high risk)
5	Integrated catchment management	Appointee (base)

Run Monte Carlo

Source: Economic Insight

When in 'Monte Carlo' mode, the model calculates the implied financial impacts - at the appointee level - associated with a 'randomly drawn' outturn level of performance (i.e. drawing from the distributions). In the model, the user can then run a 'macro' to iterate through a large number of possible outcomes (by default the model runs to 300 iterations).

As the Monte Carlo macro runs, the model stores the (appointee level) results associated with each randomly drawn outcome – as illustrated in the following figure. Impact results are generated separately for various scenarios required by Ofwat (i.e. by control area; in totality; and distinguishing C-MeX and D-MeX from other ODIs).

Figure 11: Monte Carlo outputs (illustrative only)

Monte Carlo outputs

This tab contains the outputs (£m allowed revenue impacts) arising from monte carlo RoRE risk analysis

All ODIs - revenue risk impact (£m)

	PR19									
Year	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	2027/28	2028/29	2029/30
Case 1	£44.08	£44.08	£44.08	£44.08	£44.08	£44.08	£44.08	£44.08	£44.08	£44.08
Case 2	£19.24	£19.24	£19.24	£19.24	£19.24	£19.24	£19.24	£19.24	£19.24	£19.24
Case 3	£27.52	£27.52	£27.52	£27.52	£27.52	£27.52	£27.52	£27.52	£27.52	£27.52
Case 4	£31.70	£31.36	£31.36	£31.36	£31.36	£31.36	£31.36	£31.36	£31.36	£31.36
Case 5	£18.91	£18.91	£18.91	£18.91	£18.91	£18.91	£18.91	£18.91	£18.91	£18.91
Case 6	£43.92	£43.92	£43.92	£43.92	£43.92	£43.92	£43.92	£43.92	£43.92	£43.92
Case 7	-£23.72	-£23.72	-£23.72	-£23.72	-£23.72	-£23.72	-£23.72	-£23.72	-£23.72	-£23.72
Case 8	-£74.85	-£74.85	-£74.85	-£74.85	-£74.85	-£74.85	-£74.85	-£74.85	-£74.85	-£74.85
Case 9	£9.78	£9.78	£9.78	£9.78	£9.78	£9.78	£9.78	£9.78	£9.78	£9.78
Case 10	£38.10	£38.10	£38.10	£38.10	£38.10	£38.10	£38.10	£38.10	£38.10	£38.10
Case 11	£34.45	£34.45	£34.45	£34.45	£34.45	£34.45	£34.45	£34.45	£34.45	£34.45
Case 12	-£30.32	-£30.67	-£30.67	-£30.67	-£30.67	-£30.67	-£30.67	-£30.67	-£30.67	-£30.67
Case 13	-£73.32	-£73.32	-£73.32	-£73.32	-£73.32	-£73.32	-£73.32	-£73.32	-£73.32	-£73.32
Case 14	-£0.60	-£0.94	-£0.94	-£0.94	-£0.94	-£0.94	-£0.94	-£0.94	-£0.94	-£0.94
Case 15	£15.52	£15.52	£15.52	£15.52	£15.52	£15.52	£15.52	£15.52	£15.52	£15.52

Source: Economic Insight

Finally, for each ODI RoRE risk scenario, P10 and P90 values are calculated directly from the stored appointee level results, to generate the 'low' and 'high' case impacts required by Ofwat (because the financial impacts, based on the randomly drawn ODI outcomes, are calculated at the appointee level, then the P10 / P90 values similarly reflected the probabilities at that level). The format of these outputs is shown in the next figure.

Figure 12: High and low risk scenario outputs (illustrative only)

RoRE risk analysis - results (outputs for table App26)

This sheet shows the "high" and "low" RoRE risk scenario outputs generated by the Monte Carlo analysis

Impact by price control area

ODI high RoRE case scenario (£m)	2020/21	2021/22	2022/23	2023/24	2024/25	Annual average	RoRE impact (%)
Total water network plus outcome delivery incentives (ODI) impact	£5.16	£5.11	£5.11	£5.11	£5.11	£5.12	0.23%
Total water resources outcome delivery incentives (ODI) impact	£3.96	£3.92	£3.92	£3.92	£3.92	£3.93	0.17%
Total wastewater network plus outcome delivery incentives (ODI) impact	£14.04	£13.92	£13.92	£13.92	£13.92	£13.94	0.62%
Total bioresources outcome delivery incentives (ODI) impact	£2.77	£2.75	£2.75	£2.75	£2.75	£2.75	0.12%
Total residential retail outcome delivery incentives (ODI) impact	£10.44	£10.35	£10.35	£10.35	£10.35	£10.37	0.46%
Total direct procurement for customers incentives (ODI) impact	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	0.00%
Total - impact all ODIs	£36.37	£36.05	£36.05	£36.05	£36.05	£36.12	1.60%

ODI low RoRE case scenario (£m)	2020/21	2021/22	2022/23	2023/24	2024/25	Annual average	RoRE impact (%)
Total water network plus outcome delivery incentives (ODI) impact	-£5.96	-£6.08	-£6.08	-£6.08	-£6.08	-£6.06	-0.27%
Total water resources outcome delivery incentives (ODI) impact	-£5.06	-£5.05	-£5.05	-£5.05	-£5.05	-£5.05	-0.22%
Total wastewater network plus outcome delivery incentives (ODI) impact	-£51.22	-£51.13	-£51.13	-£51.13	-£51.13	-£51.15	-2.26%
Total bioresources outcome delivery incentives (ODI) impact	-£2.47	-£2.46	-£2.46	-£2.46	-£2.46	-£2.46	-0.11%
Total residential retail outcome delivery incentives (ODI) impact	-£8.74	-£8.73	-£8.73	-£8.73	-£8.73	-£8.73	-0.39%
Total direct procurement for customers incentives (ODI) impact	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	0.00%
Total - impact all ODIs	-£73.45	-£73.45	-£73.45	-£73.45	-£73.45	-£73.45	-3.25%
Regulatory equity	£2,263	£2,263	£2,263	£2,263	£2,263	£2,263	

Impact for WaterworCX

ODI high RoRE case scenario (£m)	2020/21	2021/22	2022/23	2023/24	2024/25	Annual average	RoRE impact (%)
C-MEX (ODI) impact	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	0.00%
D-MEX (ODI) impact	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	0.00%

ODI low RoRE case scenario (£m)	2020/21	2021/22	2022/23	2023/24	2024/25	Annual average	RoRE impact (%)
C-MEX (ODI) impact	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	0.00%
D-MEX (ODI) impact	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	0.00%

Source: Economic Insight

3.3.3 Input sources

The following table provides details of the sources used to populate the key input data used in the ORRSM. Note, the next chapter of this report provides further details of the probability analysis used to define the underlying distributions relied upon.

Table 1: Input source summary

Input data	Source
Base ODI set (i.e. list of PCs, PC levels, incentive rates etc).	Yorkshire Water (primarily information use in table App1).
Probability distributions.	EI analysis of historical outcome performance + expert views within Yorkshire.
Projected RCV / regulatory equity.	Yorkshire Water Plan assumptions.
Capital type benefits (£ unit amounts).	Yorkshire Water Plan assumptions.
Financial parameters (e.g. asset lives for depreciation / WACC etc).	Derived from regulatory accounts + Yorkshire Water Plan assumptions.

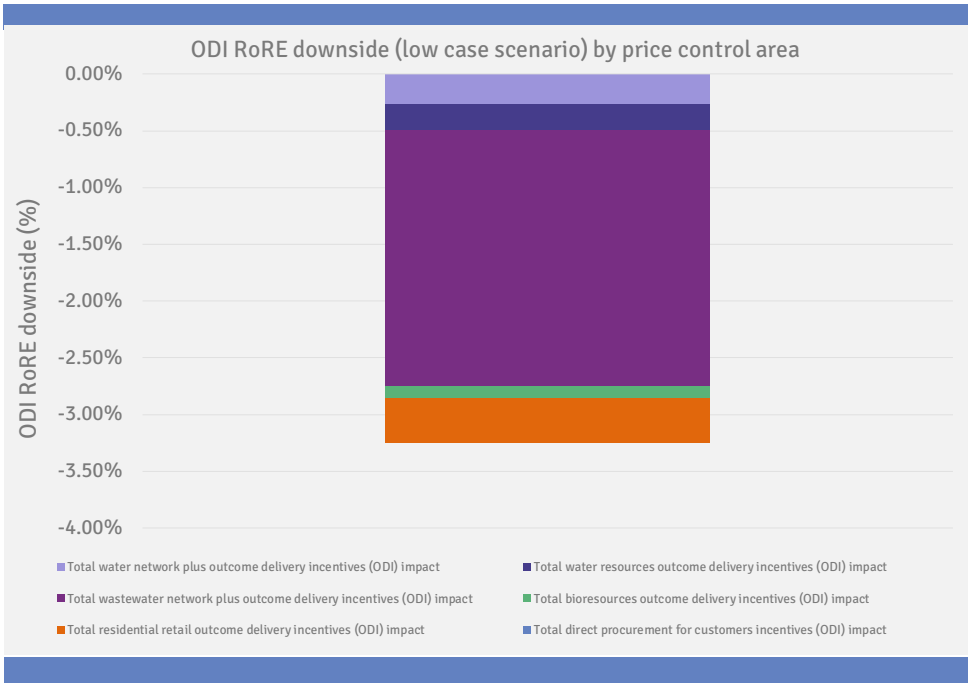
Source: Economic Insight

3.3.4 Model outputs

The ORRSM generates a range of tabular and graphical outputs to provide the user with an 'at a glance' assessment of RoRE risk. Key output formats are demonstrated in the following figures (again, using illustrative values only). They include, for example:

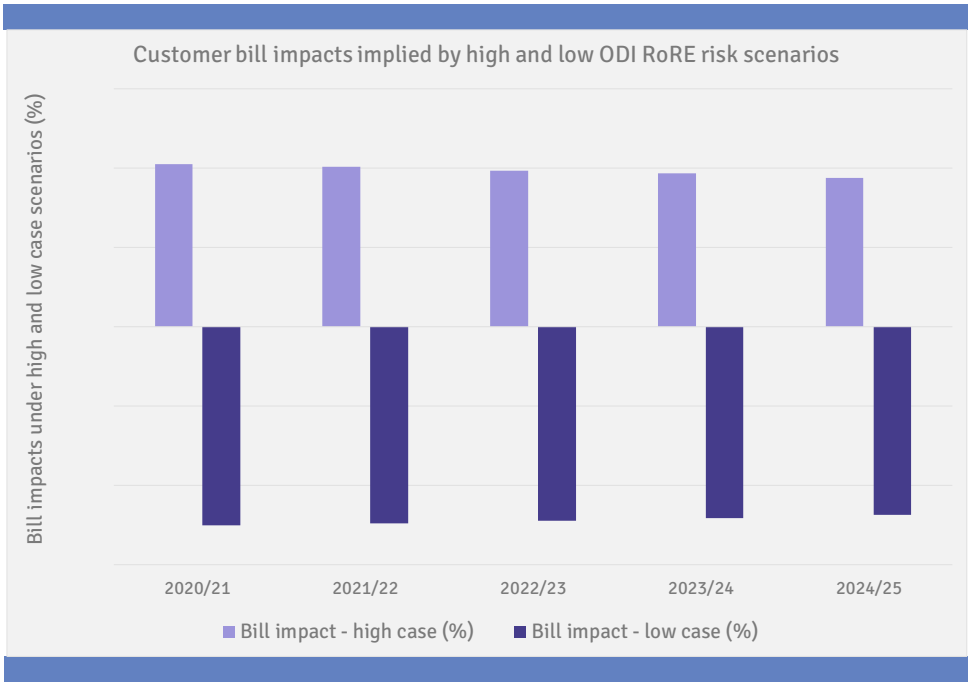
- RoRE range impacts in stacked column format (as frequently used by Ofwat).
- All outputs required by Ofwat for the population of relevant ODI related data tables.
- Percentage bills impacts for the high and low case scenarios (which are helpful when refining the overall calibration of risk, where one is interested in customer impacts).

Figure 13: RoRE range imapct (illustrative only)



Source: Economic Insight

Figure 14: Percentage bill imapcts (illusrative only)



Source: Economic Insight

THE ORRSM HAS BEEN THROUGH A HIGHLY ROBUST QUALITY ASSURANCE PROCESS – INCLUDING FULL AUDITS, EXTERNAL REVIEW, AND FEEDBACK FROM YORKSHIRE.

3.5 Quality assurance

The ORRSM has been through a robust quality assurance process, consisting of the following steps:

- Before model build, a **'model development plan'** was produced, setting out the key steps required to implement the model in a manner consistent with the overarching framework and client objectives.
- Once development began, **all model changes were logged and documented.** This allowed the team to track progress against the model development plan and ensured full transparency of calculation implementation.
- **During key stages of development, the model underwent full internal audit within Economic Insight** (i.e. all calculations and functionality was tested, and by someone other than the core model development team).
- Also, during development, **versions of the model were shared with Yorkshire, allowing them to provide feedback and views** on the model's functionality, which were then incorporated as development continued.
- **Once a finalised version of the model was developed, this was then subject to one final, full audit within Economic Insight.** Again, this consisted of a full check of all calculations and code within the model – and of all model functionality.
- Finally, once 'draft' Plan data was available, **we organised a workshop with Yorkshire where we iteratively 'ran' the model to help both 'sense check' the results**; but also advise the client on ODI risk calibration.

In totality, therefore, we are confident that the model has been through a thorough quality assurance process and is fit for purpose. The above is in addition to Yorkshire's own assurance processes, to which our work was also subject.

3.6 ODI calibration and refinement

As set out in the previous chapter, the scope of our work for Yorkshire was broader than simply providing our own assessment of ODI related RoRE risk. Rather, **our support also included providing advice and analysis to support risk calibration.** As such, the model itself was also an important tool, which was utilitised to help stress test, challenge, and ultimately refine, the company's proposed ODI package.

Following from the above, once a set of ODIs are run through the ORRSM, it is important to critically appraise the results and consider their implications. For example, suppose the indicated RoRE range appears 'wider' than might be desirable, or that potential customer bill impacts are similarly 'too high'. This, in turn, then raises questions as to 'why' this might be, allowing stakeholders to further consider the ODI proposals. For example:

- Might certain incentive rates be set "too high"? If so, is the implied risk level more acceptable when incentive rates are reduced?

- For some specific ODIs, might caps, collars, or deadbands, be required? This might be the case if one felt that both the incentive rate and underlying probability were appropriate.

- Is the probability distribution accurately capturing risk? For example, if one believed both the incentive rate and other ODI parameters were appropriate, might this imply that the assumed risk was overstated?

Consistent with the above, we worked closely with Yorkshire to help iterate through its ODI proposals as the company progressed towards finalising its Plan. This included running draft ODI packages through the ORRSM, reviewing the implied risk impacts, then providing feedback and views as to how Yorkshire might consider re-calibrating and refining its proposals. This dialogue was a continuous one, up until the company's Plan was finalised. Within this, key milestones included:

- **On May 29th we ran the company's draft ODI package through the ORRSM and provided a short summary report to Yorkshire detailing the initial RoRE range and other risk metrics.** Based on this, we provided feedback to the company that the extent of risk impacts associated with two of its ODIs (per capita consumption and external sewer flooding) appeared to be 'too high' and that, therefore, it should further refine the design of these.

- **On June 20th, we ran an all-day workshop with Yorkshire, in which we reviewed modelling outputs associated with a full draft ODI package.** Here, we carefully examined the implied RoRE impacts, understanding which ODIs were most driving them. As per the preceding discussion, we then collectively 'challenged' key design parameters and input assumptions. Key refinements / re-calibrations arising from this included:

  - Introducing enhanced out and underperformance incentive rates for per capital consumption.
  - Introducing enhanced out and underperformance incentive rates for leakage.
  - Developing and applying additional probability distributions for certain ODIs, based on 'expert views' within the business.
  - Applying additional deadbands to a limited number of ODIs, where *minor* variation around the PC appeared to disproportionately drive value (and may not be mainly within company control). These included, for example: drinking water quality; water supply interruptions; and leakage.

- Since the above workshop, **Yorkshire continued to use the model to 'fine-tune' the design of its ODI package.**

THE SCOPE FOR RISK MITIGATION BY YORKSHIRE WAS AN IMPORTANT PART OF OUR ANLAYSIS.

3.8 Risk management and mitigation

As previously summarised, Ofwat's PR19 methodology states that, when assessing ODI RoRE risk, companies should take into account the steps they can implement to mitigate and manage risk. Accordingly, we ensured that this was taken into account within the scope of our analysis for Yorkshire. In practical terms, this was achieved as follows:

- For the most material ODIs, we sought views from the business as to what the main risk management and mitigation steps would be to help address performance risk.
- Having gathered these, when working with Yorkshire to assign probability distributions to individual ODIs within our model, **we ensured that the mitigating actions formed part of the discussion – and were therefore taken into account.**

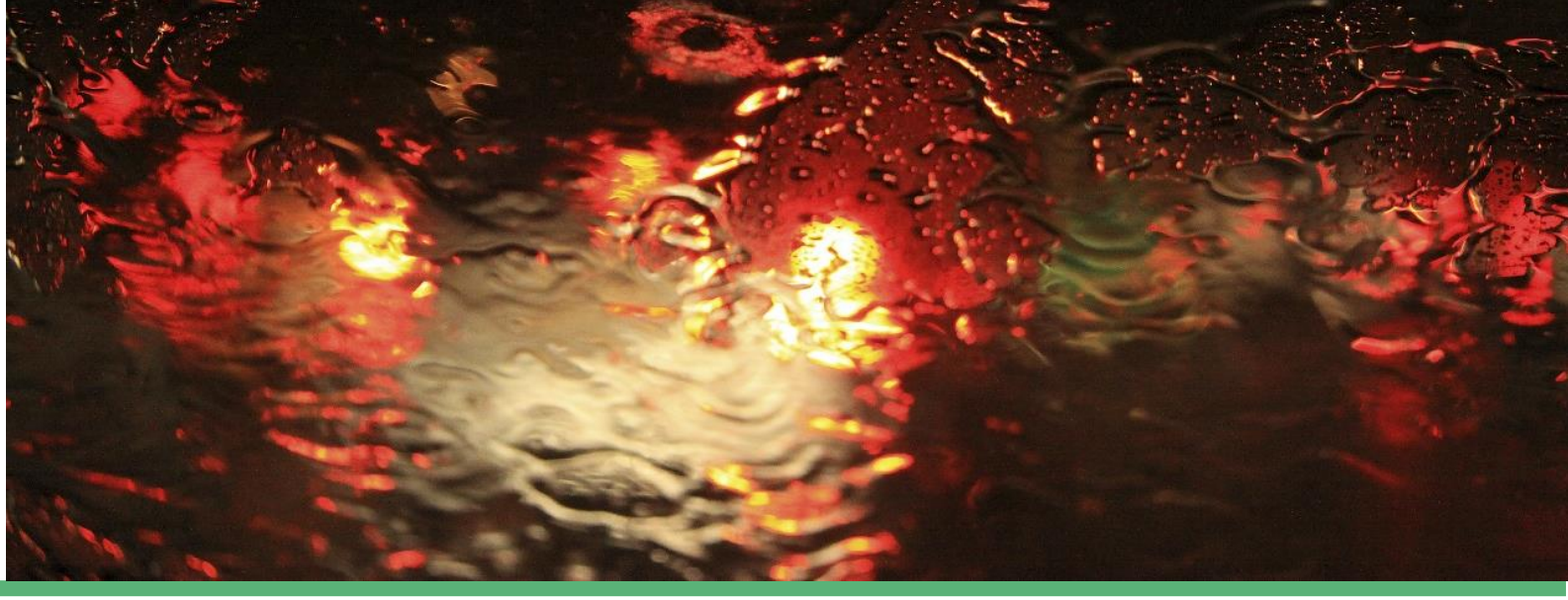
The following table summarises the most important mitigations identified through the above process, and which were therefore incorporated within our modelling.

Table 2: Key risk mitigating actions taken into account within modelling

ODI	Key risks	Key risk management / mitigation actions identified and taken into consideration in modelling
Working with Others	Ability to achieve this target is partly dependent on funding and resources of our potential partner organisations.	YW will maintain strong relationships with partner organisations to deliver a similar level of performance throughout AMP7. YW also expects to be able to reinvest the modest rewards gained in AMP6 to seed fund further partnerships in AMP7.
Land Conserved and Enhanced	The greatest risks to achieving performance is in the available resources of YW and Natural England to support the delivery of the SSSI programme.	Both can be mitigated by ensuring sufficient future resource is present, either through YW staff, or through using Natural England's commercial Discretionary Advice Service, as has been done successfully in the past.
Length of River Improved (LORI)	The LORI targets for clean & waste programmes are driven by WINEP requirements. The performance for these will be agreed in 2023, once WINEP schemes are finalised. The risk is around the total cost and deliverability of these schemes being larger than anticipated.	A risk-based approach will be taken to project delivery: the projects of highest risk will be started first, allowing time to accommodate any delays caused by these.
Operational Carbon	Risks beyond YW control, such as extreme weather, UK emissions factor, and the final extent of the WINEP programme.	YW has made this an end of AMP target, to help minimise the impact of annual fluctuations in factors outside of its control.
Education	Change in measure, to hours, rather than no. of children, puts some risk on confidence - as this metric was not previously recorded.	YW is looking to increase outreach work, opening a centre for another day, to be able to deliver more. YW will manage bookings proactively and will aim to book 10% extra to mitigate against cancellations. A new education portal has been developed to track weekly what has been delivered - numbers and hours. This will allow YW to forecast and respond accordingly.
Awareness of Priority Services Register (PSR)	Without programmes, there would be no improvement in the performance. Risk that surveying customers to provide performance commitment outturns could lead to unpredictable results.	Schemes identified to support this performance commitment, including: communications, partner engagement, staff training, joint promotion work with Northern Power Grid. There is a communications plan to increase customer awareness. Through programme, will track what is affective and will work with this going forward.

Meeting vulnerable customer needs	YW has not measured this before, so there is uncertainty in the data.	Schemes are identified to support this performance commitment, including changes in PSR info recorded, meeting with inclusive service group, etc. YW will work with the inclusive customer service group to identify better ways to provide services and possibly new services, as well as getting reviews and input from national charities. In addition, the tracker developed to measure this performance will measure satisfaction, but will allow customer feedback, thus allowing YW to continually engage on gaps in delivery and develop the service based on feedback.
Drinking Water Quality (CRI)	The data we are building the forecast on is only for a few years and is very volatile. As such, there is great uncertainty about the trend to inform future performance. 1 year of industry data in turn makes this hard to predict the UQ position.	Deliver improvement through: (1) metaldhyde catchment management. This would benefit from a full government ban on metaldhyde (possible) or catchment management solutions as alternative to deliver performance; (2) DWI Schemes; (3) flushing programme; and (4) Some contribution from UQ Plan. A CRI transformation strategy is being developed to review and amend how YW operates. Very early stages, but will take a risk-based approach to managing sites and processes.
Water Supply Interruptions (Customer Minutes Lost)	UQ plan to deliver the frontier performance on this commitment. 2 mins would put us at frontier & is the best possible performance.	There are numerous schemes identified to deliver this commitment, including 24 7 Engineering Support, Enhanced Review and Reporting, Improving Capability, Increased Logger Coverage and Asset Visibility amongst others.
Leakage	There has never been such a large jump in improvement over such a short time. The risk is that it becomes increasingly harder to identify leaks as performance improves (the easy ones are found first). Thus, ongoing improvements are very reliant on the development of technologies and innovation to ensure ongoing performance.	Several measures in place as part of the UQ plan to get to target: Smart metering, acoustic loggers, pressure management, etc. Engagement with the supply chain to develop new approaches to meeting this target.
Mains Repairs	Theoretically it is possible to reduce the number of mains repairs to extremely low levels, but this will have a negative impact on leakage performance.	Initiatives that will help maintain or reduce bursts: pressure management, smart or calm network initiatives, calm network training of all field staff, pump efficiency and variable speed pumping, improved demand management. All these initiatives are part of our plans for AMP7, but quantifying the benefit is difficult, and will be unlikely to provide any reduction in overall mains repairs given the drive to reduce leakage.
Per Capita Consumption	The performance of this PC is heavily driven by customer participation. There is also the risk that extreme weather (hot summers) would increase usage beyond the normal peak.	Efficacy promotion schemes to deliver improvement to some extent. Regarding the extreme weather risk, there is currently a method to account for this in AMP6, but it isn't effective, so has been removed for AMP7. We can assume the impact can be mitigated through the above schemes and the annual average. Further effort in customer participation and outreach schemes is planned
Drinking water contacts	We have set our target on the proportional equivalent of what the AMP6 UQ would be, without including illness contacts. This is a stretching performance and one that we are yet to achieve.	To deliver this, we will complete a mixture of Distribution Monitored Area (DMA) flushing, automated trunk mains conditioning, and a small amount of capital activity, to minimise contacts. We are looking to understand the maximum possible performance offered by DMA flushing, but will be monitoring performance and projections.
Water Supply Interruptions (12 hours or longer)	Performance will be susceptible to severe weather. The target of one interruption >12 hours per month is considered stretching.	The Frontier plan for customer minutes lost (CML) will have a benefit to this PC, as will the other resilience schemes in relation to water treatment works and water networks, but this will be a longer-term initiative to improve this to the levels that we would ideally like to get to.

Source: Economic Insight



4. Performance risk analysis (probabilities)

In this chapter, we describe our analysis of underlying ODI performance risk, which was used to help define the probability distributions used within the Monte Carlo functionality of the model. Here, we drew on two main sources of information, which we address in turn: (a) analysis of historical ODI data; and (b) expert industry judgement and views.

4.1 Using historical ODI data to understand performance risk

1.4 Key calculation steps

One helpful way of understanding performance risk at PR19 is to examine outturn ODI performance over the first two years of PR14. In particular, if one assumes that the difference between the PR14 PC levels and outturns relates to underlying risk, then it is possible to define associated probability distributions. To implement this approach in practice, we undertook the following steps:

- For each ODI at PR14, we calculated the *percentage* variation between the PC level and the outturn result.[7] In doing so, we normalised for the direction of improvement.
- We then 'grouped' ODIs by price control area, *pooling observations across companies.*
- Using this information, we then derived both **'triangular'** and **'normal'** distributions for ODIs at the price control level. This was done by calculating the key input parameters needed to 'draw' distributions (i.e. for triangular, the minimum, maximum and most likely outcome; and for normal, the mean and standard deviation).

[7] *Note, the use of 'percentage' variation to define the distributions is important here, because: (i) it allows us to pool observations across companies more easily – say, for example, where ODI metrics might differ at a more detailed level for a similar outcome; and (ii) because once distributions are estimated, they can (if desirable) be applied across more than one ODI.*

- From the above, we then had 12 'base case' ODI performance risk distributions (i.e. one for each price control area * 2 for the triangular and normal distributions).

The implications of the approach we adopted are as follows:

  - By pooling the observations by price control area, and across companies, we increased the number of data points from which the distributions are estimated. All else equal, this should increase their robustness. In addition, we consider that looking at variance across multiple companies is more likely to capture 'underlying performance risk' at PR19, rather than picking up 'company specific' capability.
  - Conversely, if a company felt that its underlying performance was (for some reason) systemically different from the average, the above approach would be less appropriate. In which case, alternative methods for estimating probability distributions (such as using company specific data, albeit with far fewer data points) or expert judgement, might be preferred.
  - By calculating distributions at the price control level, rather than by individual ODI, one is not assuming that financial risk is the same for all ODIs within a control. This is because: (i) by defining the distributions in terms of a percentage deviation from the PC, for any individual ODI those variations would imply very different performance levels; and (ii) the financial risk exposure is also a function of incentive rates, which are separately applied within our model calculations.

Randomly generated values for a **triangular distribution** are derived as follows:

$$X = \begin{cases} a + \sqrt{U\,(b-a)(c-a)} \\ b - \sqrt{(1-U)(b-a)(b-c)} \end{cases} \quad \begin{matrix} for\ 0 < U < F(c) \\ for\ F(c) \leq U < 1 \end{matrix}$$

Where:

- a is the minimum value;
- b is the maximum value; and
- c is the most likely (mode).

The standard **normal distribution** is defined as:

$$f(x \uparrow \mu, \delta^2) = \frac{1}{\sqrt{2\pi\delta^2}}\, e - \frac{(x-\mu)^2}{2\delta^2}$$

Where:

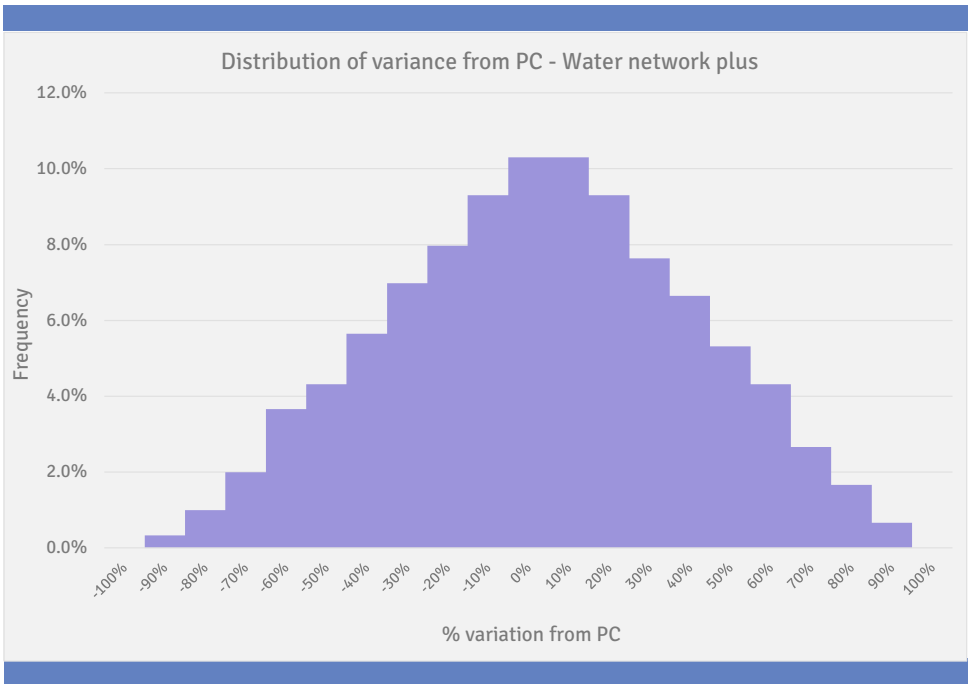
- u is the mean (or expectation);
- δ is the standard deviation; and
- δ^2 is the variance.

Randomly generated values from a standard normal distribution are derived by calculating the inverse cumulative density function (this can be done within Excel using the *'norm.inv'* function).

1.5 Summary of estimated distributions

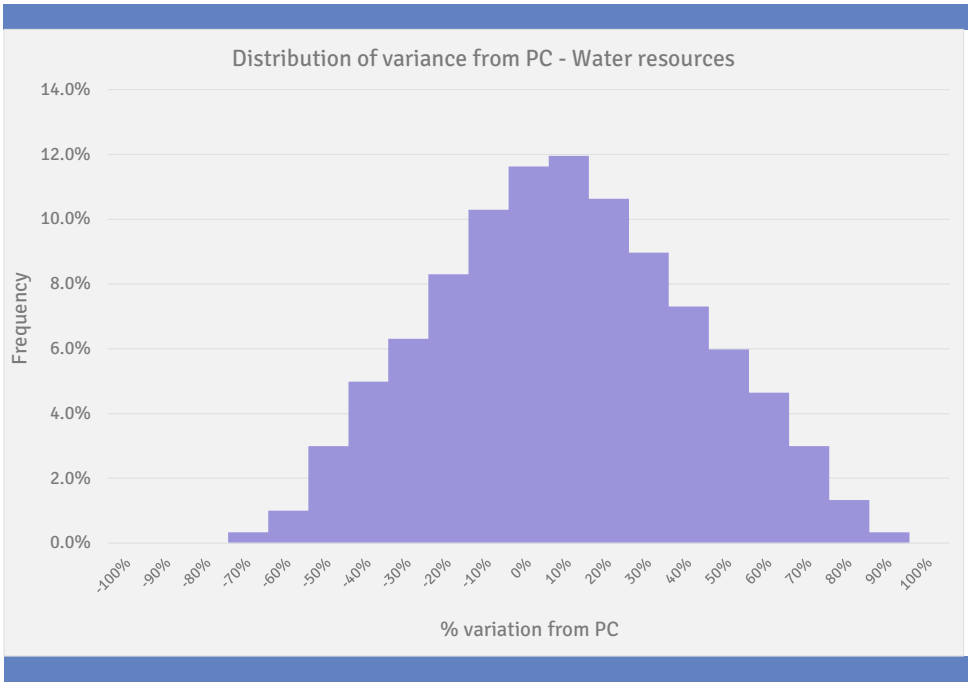
Using the approach detailed above, the following figures show our base case (triangular) probability distributions by price control area.

Figure 15: Water network plus – base case triangular distribution



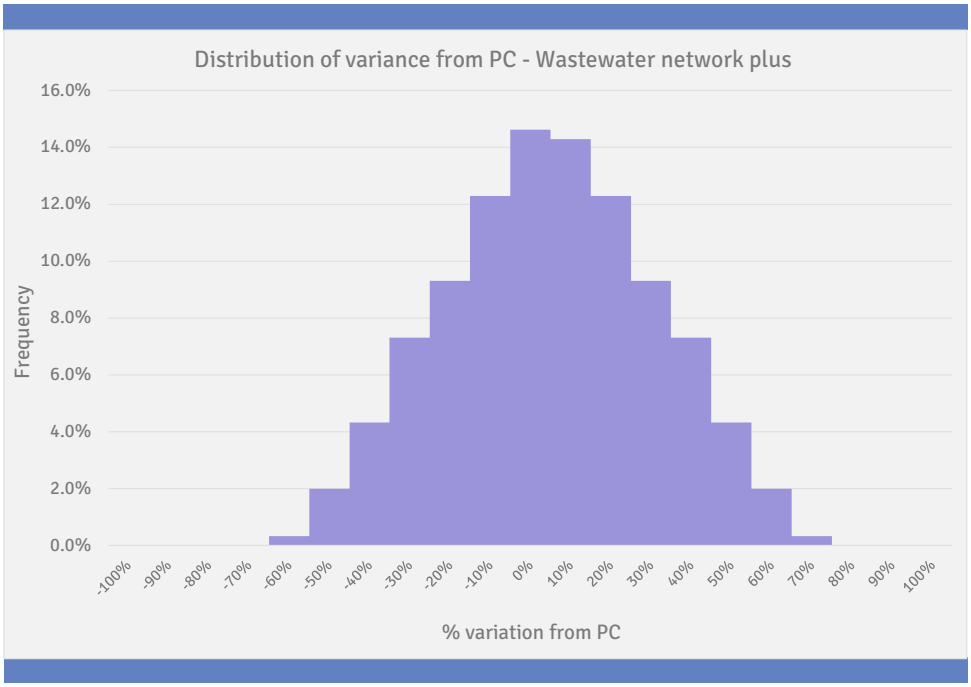
Source: Economic Insight

Figure 16: Water resources – base case triangular distribution



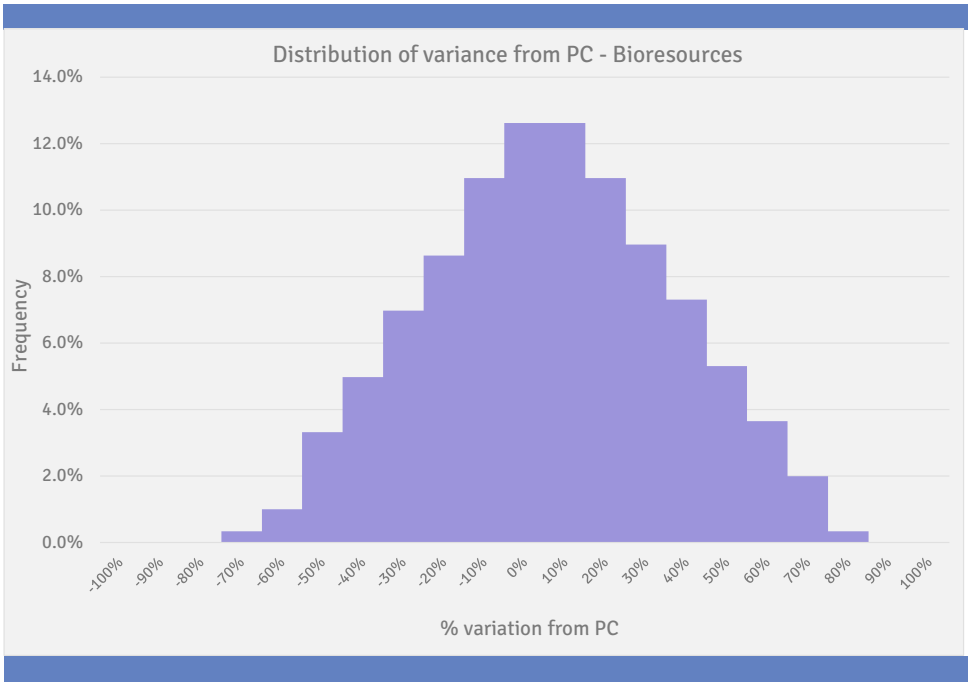
Source: Economic Insight

Figure 17: Wastewater network plus – base case triangular distribution



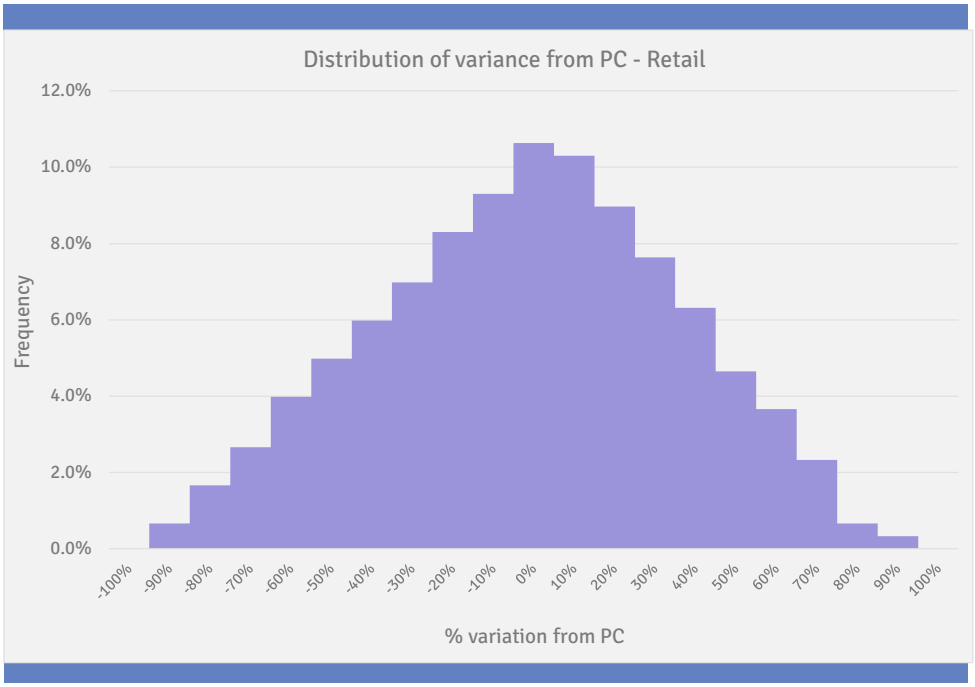
Source: Economic Insight

Figure 18: Bioresources – base case triangular distribution



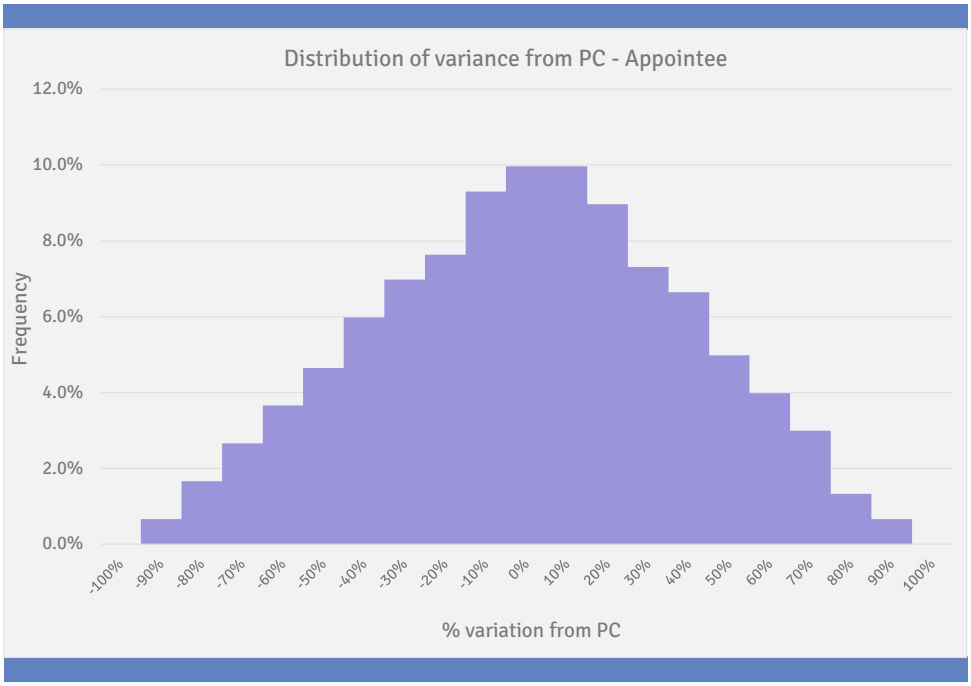
Source: Economic Insight

Figure 19: Retail – base case triangular distribution



Source: Economic Insight

Figure 20: Appointee – base case triangular distribution



Source: Economic Insight

Drawing on the same analysis, the following table summarises the key parameters used to derive the distributions.

Table 3: Probability distribution parameters

Parameter	Water resources	Water network plus	Waste-water network plus	Bio-resources	Retail	Appointee
Mean variation from PC (%)	4%	-2%	0%	1%	-6%	-4%
Standard deviation (%)	32%	38%	26%	30%	37%	39%
Min variation from PC (%)	-72%	-94%	-63%	-71%	-100%	-100%
Max variation from PC (%)	84%	87%	62%	74%	80%	87%
P90	48%	48%	35%	42%	43%	47%
P10	-72%	-52%	-35%	-39%	-57%	-57%

Source: Economic Insight

WHILST WE ESTIMATED BOTH NORMAL AND TRIANGULAR DISTRIBUTIONS, IN PRACTICE WE FOCUSED ON THE TRIANGULAR APPROACH – WHICH IS WIDELY APPLIED IN MONTE CALRO RISK ANALYSIS.

In addition to estimating the above 'base case' distributions, we further derived 'low risk' and 'high risk' variants for each – as follows:

- For 'low risk', we assumed the min and max values were 70% of the base case.
- For 'high risk', we assumed the min and max values were 130% of the base case.

The purpose of the 'low' and 'high' risk variants is to provide a broader set of probability distributions to draw upon – allowing any model user to make use of whichever they consider to 'most reflect' the underlying risk of the ODI in question. Accordingly, in total we arrived at 36 distributions (i.e. the 12 as above * 3 for the 'base', 'low' and 'high' risk variants).

1.7 Advantages of triangular distributions

In practice when running our ORRSM for the purpose of assessing Yorkshire's ODI RoRE risk, we focused on triangular (rather than normal) distributions. This is for a number of reasons, including:

- Where there is uncertainty as to the "true" distribution of a variable, the parameters required to estimate a triangular distribution (min, max and most likely) are relatively intuitive, meaning that stakeholders can reasonably review and challenge values derived from data, or propose values of their own.

- In many cases, a triangular distribution will approximate a log-normal distribution. Consequently, even if one 'expected' the true distribution to be log-normal, the intuitive advantages of a triangular approach (as per above) are likely to outweigh any small measurement accuracy loss.

'The triangular distribution provides very similar results to that of other distributions for the same mean and standard deviation.' – Viser

Reflecting the above, in practice triangular distributions are commonly used within risk analysis more broadly; and Monte Carlo analysis more specifically. There is, therefore, a range of academic research and literature that advocates their use. For example, Vose states: *"The triangular distribution is the most commonly used distribution for [risk] modelling… [and] has very obvious appeal because it is easy to think about the three defining parameters and to envisage the effect of any changes."*[8] Similarly, Viser notes: *"the triangular distribution provides very similar [Monte Carlo] results to that of other distributions for the same mean and standard deviation."*[9]

4.2 Expert industry views within Yorkshire

The main advantage of the preceding approach is that it allows probability distributions to be defined based on actual data relating to ODI performance. This therefore, provides both a high degree of transparency, but also a level of robustness and assurance. However, whilst we consider that such analysis provides a reasonable basis for identifying underlying performance risk, we also recognise that there might be circumstances where it might be appropriate to depart from it. For example, this may be the case if, for the ODI in question:

- Yorkshire believed its underlying risk profile was different from the industry average;
- the ODI was 'new' and there were reasons to suppose that its underlying risk profile different from the historical performance risk observed for ODIs more generally; and / or
- that on a forward-looking basis, expected performance had 'changed', relative to historical risk.

Given this, we supplemented our historical analysis by seeking 'expert views' from within Yorkshire. Specifically, key operational stakeholders were given the opportunity to provide their views on the 'minimum'; 'maximum' and 'most likely' performance levels across the set of proposed ODIs. From these, we again derived (triangular) probability distributions, using a 'probability distribution generator' template Excel file, which we provided to Yorkshire (see following figure).

[8] *'Risk analysis: A Quantitative Guide.' David Vose (2008).*
[9] *'Comparison of probability distributions for use in reliability and maintainability simulation.' JK Viser in 'Safety and Reliability of Complex Engineered Systems.' Taylor & Francis Group (2015).*

Figure 21: Probability distribution generator spreadsheet (illustrative figures only)

Probability distribution generator

This tab generates ODI probability distributions for the ODI model, based on user assumptions

ODI Name		Internal sewer flooding
Performance measure (units)		Flooding incidents pa
PC level (in same units as above)		100
Assumed most likely actual performance level		100
Minimum assumed level		50
Maximum assumed level		150
Triangle distribution parameters		
Min		-50.00%
Most likely		0.00%
Max		50.00%
Lower range		50.00%
Higher range		50.00%
Total range		100.00%

Triangle distribution calculations

Probability	Flag	If 1	If 2	Triangle dist. outcome
0.000000	1	-0.499776	-0.207107	-0.499776
0.003333	1	-0.459177	-0.205927	-0.459177
0.006666	1	-0.442267	-0.204746	-0.442267
0.009999	1	-0.429293	-0.203563	-0.429293
0.013332	1	-0.418354	-0.202377	-0.418354
0.016665	1	-0.408717	-0.201190	-0.408717
0.019998	1	-0.400005	-0.200001	-0.400005
0.023331	1	-0.391993	-0.198809	-0.391993
0.026664	1	-0.384536	-0.197616	-0.384536

Source: Economic Insight

FOR FOUR ODIs, YORKSHRE IDENTIFIED UNDERLYING PROBABILTIY DISTRIBUTIONS FOR PERFORMANCE RISK BASED ON 'EXPERT VIEWS'.

In total, four additional distributions were identified based on 'expert views'. These related to the following ODIs:

- leakage;
- mains repairs;
- per capita consumption; and
- external sewer flooding.

4.3 Applying probability distributions within the model

As previously set out in the description of our models' functionality, ultimately the user can 'assign' probability distributions at the individual ODI level. Accordingly, drawing on both evidence sources outlined in the previous sections, Yorkshire selected the probability distributions it considered most appropriate for each (financial) ODI included in its PR19 Plan. The choice of distribution was further considered at the workshop (as described in the previous chapter of this report) as part of the broader process for refining Yorkshire's finalised ODI package.

In assigning distributions, Yorkshire explicitly took into account the 'direction of improvement', to ensure that the implied min and max values for out and underperformance accorded with their best views.

5. RoRE risk scenario results

This chapter of our report sets out the results of our RoRE risk modelling for Yorkshire. Overall, we find that the RoRE range associated with Yorkshire's proposed ODI package is between -2.11% and +1.92%. The company's ODI risk exposure is primarily concentrated in the water and wastewater network plus price control areas. By 'ODI type', value is most concentrated in 'environmental'; 'customer service'; and 'asset health' ODIs. Bill impact analysis suggests that ODI out and under performance is likely to account for no more than -7% to +6% of customer bills.

In the following we set out in turn:

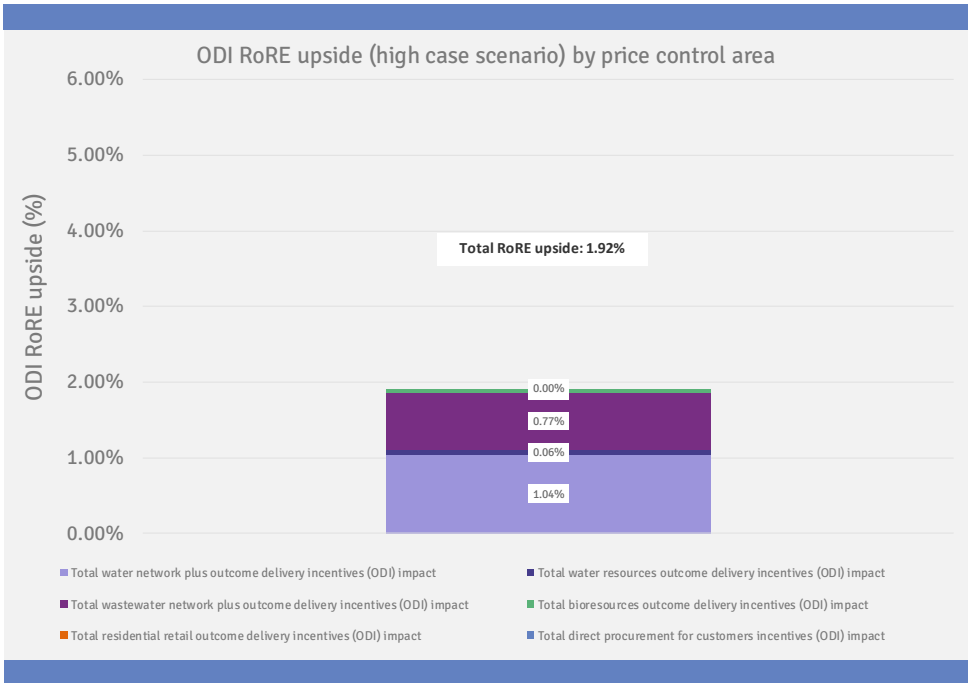
- The overall ODI RoRE risk range implied by our modelling.
- How the impacts are split by ODI type.
- Customer bill impact analysis.

5.1 Overall RoRE range results

In summary, our Monte Carlo RoRE risk modelling suggests that the RoRE range associated with Yorkshire's ODI package is -2.11% to +1.92%.

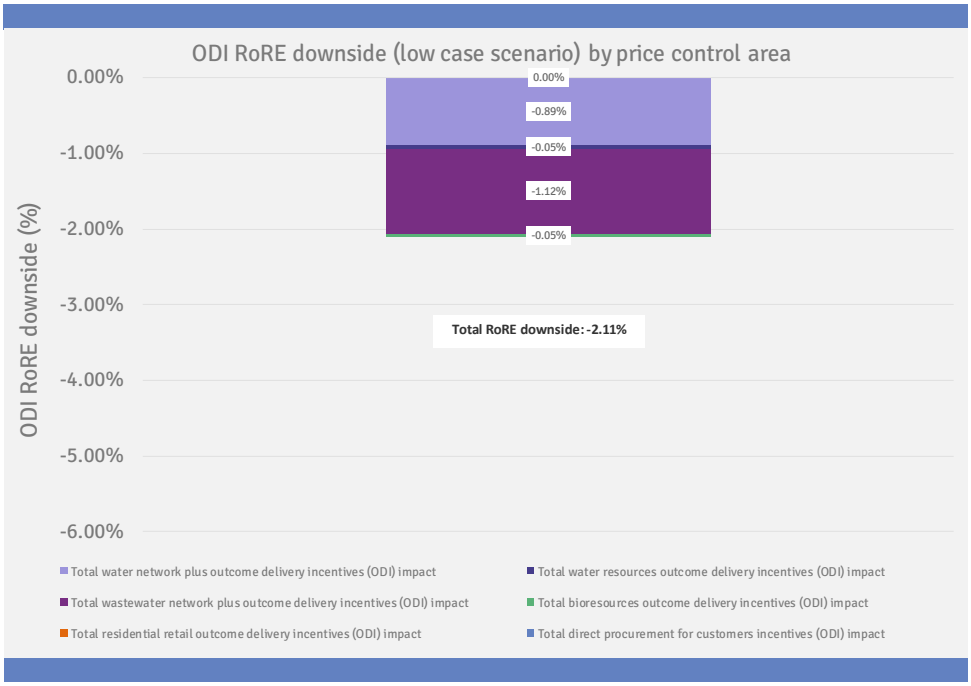
The following figures provide a graphical summary of the split of the overall range by price control area, in a 'stacked column' format, as typically utilised by Ofwat.

Figure 22: ODI RoRE range impact - upside



Source: Economic Insight

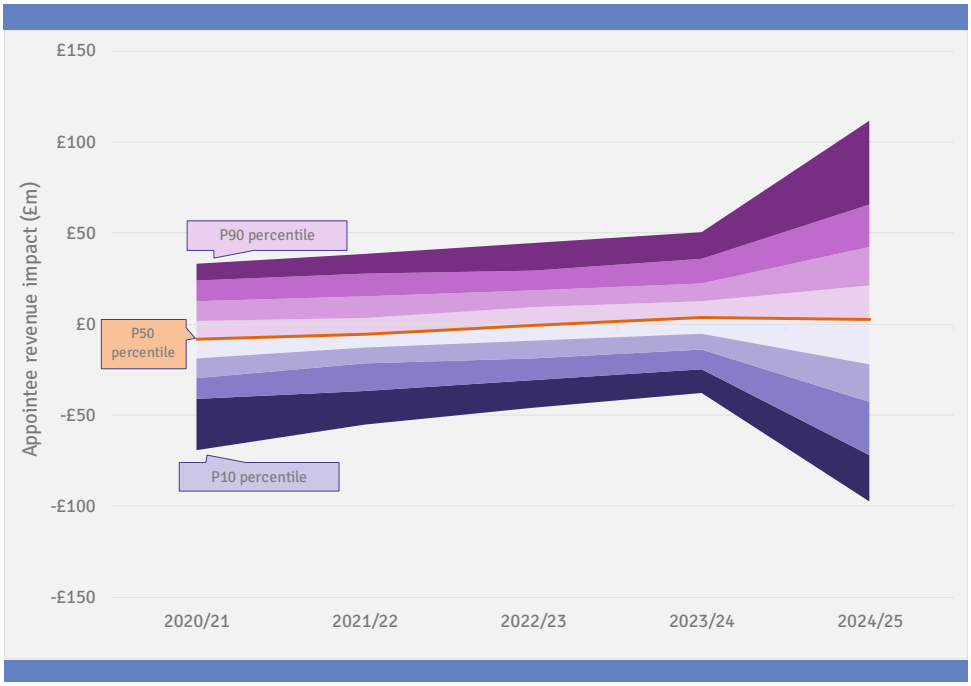
Figure 23: ODI RoRE range impact - downside



Source: Economic Insight

The following figure shows a 'fan chart' of the spread of potential financial impacts arising from ODI performance, at the appointee level. Each shaded area represents a percentile, ranging from the P10 to the P90. Consistent with the slight downside skew, the P50 £m impacts are very slightly negative. The spread of impacts widens in the final year, due to Yorkshire having a limited number of end-of-period ODIs within its package.

Figure 24: Fan chart of appointee level financial impacts over PR19



Source: Economic Insight

The following tables set out the financial impacts for the high and low case scenarios, based on our Monte Carlo modelling, in the format required to populate table *App26*.

Table 4: ODI RoRE risk impacts – high case

ODI high RoRE case scenario (£m)	2020 / 21	2021 / 22	2022 / 23	2023 / 24	2024 / 25	Annual average	RoRE impact (%)
Total water network plus outcome delivery incentives (ODI) impact	£21.04	£25.16	£30.63	£35.95	£38.86	£30.33	1.04%
Total water resources outcome delivery incentives (ODI) impact	£0.07	£0.08	£0.09	£0.10	£7.83	£1.63	0.06%
Total wastewater network plus outcome delivery incentives (ODI) impact	£12.17	£13.20	£13.81	£14.31	£57.63	£22.22	0.77%
Total bioresources outcome delivery incentives (ODI) impact	£0.00	£0.00	£0.00	£0.00	£7.66	£1.53	0.05%
Total residential retail outcome delivery incentives (ODI) impact	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	0.00%
Total direct procurement for customers incentives (ODI) impact	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	0.00%
Total - impact all ODIs	£33.28	£38.45	£44.53	£50.37	£111.98	£55.72	**1.92%**

Source: Economic Insight

Table 5: ODI RoRE risk impacts – low case

ODI high RoRE case scenario (£m)	2020 / 21	2021 / 22	2022 / 23	2023 / 24	2024 / 25	Annual average	RoRE impact (%)
Total water network plus outcome delivery incentives (ODI) impact	-£44.54	-£32.48	-£22.54	-£16.32	-£13.26	-£25.83	-0.89%
Total water resources outcome delivery incentives (ODI) impact	-£0.11	-£0.11	-£0.12	-£0.12	-£6.91	-£1.48	-0.05%
Total wastewater network plus outcome delivery incentives (ODI) impact	-£24.62	-£22.69	-£23.48	-£21.46	-£70.22	-£32.49	-1.12%
Total bioresources outcome delivery incentives (ODI) impact	-£0.01	-£0.01	-£0.01	-£0.01	-£7.07	-£1.42	-0.05%
Total residential retail outcome delivery incentives (ODI) impact	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	0.00%
Total direct procurement for customers incentives (ODI) impact	£0.00	£0.00	£0.00	£0.00	£0.00	£0.00	0.00%
Total - impact all ODIs	-£69.27	-£55.29	-£46.15	-£37.91	-£97.46	-£61.22	**-2.11%**

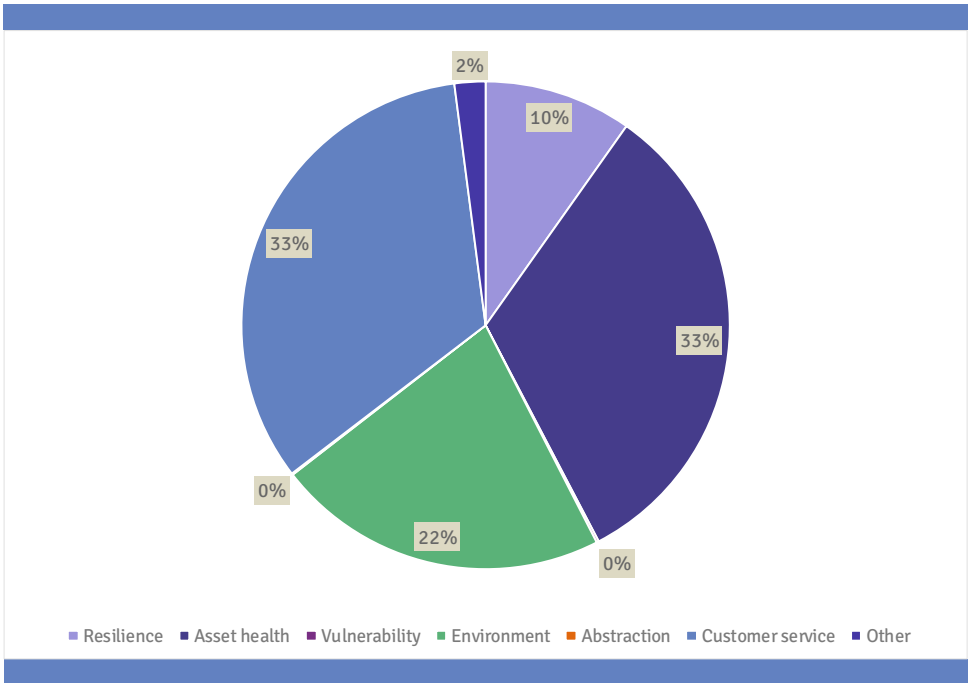
Source: Economic Insight

5.3 ODI RoRE risk impacts by 'ODI type'

We have also analysed the above results across 'ODI type' (i.e. resilience, asset health etc). There are various ways of summarising financial impacts by ODI type. However, we consider that the 'share of financial upside' or 'share of financial downside' is a helpful way to think about this. Accordingly, the pie charts below show the proportion of the P90 and P10 revenue impact at the appointee level, by category.

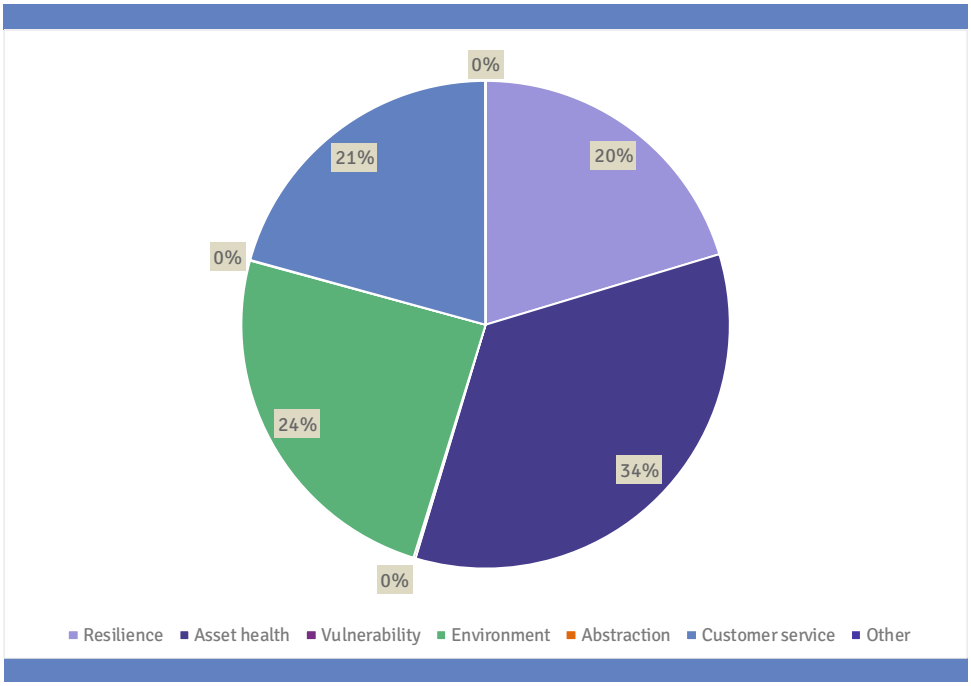
YORKSHIRE'S ODI PERFORMANCE VALUE AT RISK IS MOST CONCENTRATED IN: ASSET HEALTH; ENVIRONMENT; AND CUSTOMER SERVICE.

Figure 25: Share of ODI P90 imapct by ODI type



Source: Economic Insight

Figure 26: Share of ODI P10 imapct by ODI type



Source: Economic Insight

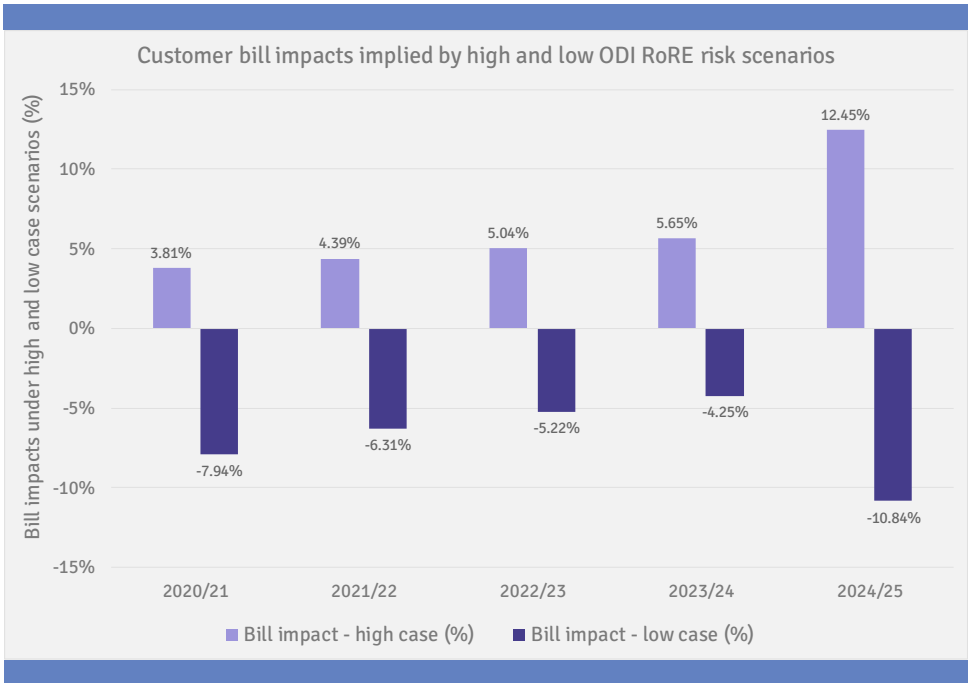
Relating to the above, we find that value is most concentrated in: 'asset health'; 'the environment'; and 'customer service'.

BILL IMPACT POTENTIAL RANGES FROM -7% TO +6%. THIS IS BROADLY IN LINE WITH IMPACT POTENTIAL SEEN AT PR14.

5.4 Customer bill impact analysis

Based on the outputs of our Monte Carlo modelling, we have further examined the potential scope of bill impacts under the 'high' and 'low' case scenarios. We find that ODI out and underperformance by Yorkshire could impact bills by between -7% and +6%, on average over PR19. We consider that this represents an appropriate range and is broadly in-line with bill impact potential across the industry at PR14.

Figure 27: Scope of bill impacts



Source: Economic Insight

6. Conclusions and recommendations

This final chapter of our report sets out our conclusions and recommendations. Overall, the approach set out here, analytical methods, and their application, mean that Yorkshire has a thorough and comprehensive assessment of the RoRE risk associated with its ODI package at PR19. The implied RoRE risk range of -2.11% to +1.92% is in line with Ofwat's guidelines. Importantly, the (modest) skew to the downside is both consistent with economic theory - and is what we would expect to observe from a company submitting an ambitious Plan. Going forward, our recommendations include suggesting that Yorkshire embed this risk analysis as part of 'business as usual' and update its understanding of RoRE risk as more data becomes available.

6.1 Conclusions

The key conclusions arising from our work for Yorkshire are as follows:

- **Overall, we consider that the totality of evidence and analysis presented in this report provides Yorkshire with a robust, comprehensive and objective assessment of ODI risk at PR19.** In particular, key beneficial features of the approach that should be highlighted are that: (i) it is underpinned by a sound framework; (ii) it utilises Monte Carlo techniques in order to avoid making simplistic assumptions about the independence of risk; (iii) the underlying inputs are based on the best available data (as noted above, this includes probability distributions derived from outturn PR14 performance); (iv) the approach was not simply to provide Yorkshire with 'results'; but rather, to use our modelling tool as an input into calibration and refinement. As such, this gives further confidence as to the appropriateness of the company's finalised ODI package.

- It is fundamentally challenging to measure underlying performance risk for ODIs – primarily because of their relative recentness. This means that, even for ODIs that already exist, there are relatively limited data points that can be used. Given this, we think it is particularly valuable to look at risk 'across the industry' and to (where possible) identify underlying risk based on industry data. In addition, however, given the inherent limitations, we also think there is a role for 'expert

opinion'. Accordingly, we think that **approaches which blend both 'data' and 'expertise' (such as that deployed here for Yorkshire) are preferable at PR19.**

- **The implied ODI range of -2.11% to +1.92% is within Ofwat's guideline ODI range for PR19 (which is +/- 1% to 3%).** This provides further assurance as to the likely reasonableness of the risk exposure associated with the company's ODI package.

YORKSHIRE'S ODI PACKAGE IS MODESTLY SKEWED TO THE DOWNSIDE. THIS IS CONSISTENT WITH ECONOMIC THEORY, BUT IMPORTANTLY, ALSO WITH THE COMPANY'S PLAN BEING AN AMBITIOUS ONE.

- **The company's ODI risk is <u>moderately</u> skewed to the downside.** In our view, this is consistent with both economic theory – and with the company's Plan being 'ambitious'.
  - » In relation to the former, if one assumes that PC levels should (typically) be set at the economically efficient level, then the rationale for financial penalties (in cases where companies under-perform) is clear. However, the rationale for rewards (where companies over-perform) is more complex. Typically, if the PC is 'correctly' identified, then customers should not be asked to fund service levels beyond their own valuation. Circumstances whereby rewards *might* be appropriate could include: (i) measurement error in setting the PC rate; (ii) reductions in the marginal cost of delivering the outcome, meaning that the economically efficient service is 'higher' than the PC; and / or (iii) if 'over-delivery' now might drive dynamic efficiency gains to customers in future (e.g. such as Ofwat's rationale regarding the benefits of 'driving the frontier'). Consequently, whilst there clearly are good reasons to have reward payments, the preceding implies: (i) that there should be some ODIs that are 'penalty only'; and (ii) that in some cases, penalty rates should exceed reward rates. **Thus, economic theory suggests that, across the industry, one might expect to see a (modest) skew to the downside on ODI risk.**
  - » In relation to the latter, if a company were submitting a particularly ambitions Plan (say if it was aiming for 'fast track' or 'exceptional' status) this provides a further rationale for its ODI package to have a modest skew to the downside. That is to say, **in our view, a genuinely ambitious company should be setting the most stretching of targets, and not submitting unduly generous incentive rates.** Therefore, all else equal, an ambitious company might expect 'under-performance' against its PCs to be somewhat more likely than 'outperformance' – such that only by performing to the very best of its capabilities will upside be realised.

- **The company has taken a holistic approach to risk calibration, taking into account its risk exposure across other areas of its Plan.**

WE RECOMMEND YORKSHIRE EMBEDS THIS TYPE OF RISK ANALYSIS AS PART OF 'BUSINESS AS USUAL' – IN PARTICULAR, GIVEN THE RECENTNESS OF ODIs, IT IS IMPORTANT TO DRAW ON NEW PERFORMANCE DATA AS IT BECOMES AVAILABLE, SO THAT THE COMPANY CAN CONTINUALLY REFINE ITS UNDERSTANDING OF RISK.

3. Recommendations

Following from the above, we have three recommendations:

- **Having developed this approach to risk analysis, Yorkshire should seek to embed it as part of 'business as usual' going forward.** In particular, given the uncertainty regarding underlying performance risk (mainly due to the recentness of ODIs) it will be important to utilise new information as it becomes available to test whether this impacts prevailing assumptions regarding risk. Where new information materially affects the company's views on risk, we would further recommend re-running the Monte Carlo analysis to help understand the likely implications for RoRE ranges.

- **Yorkshire should monitor and evaluate the effectiveness of its risk-mitigation strategies.** As explained elsewhere in this report, the company's views on risk incorporated within our analysis explicitly take into account Yorkshire's ability to mitigate risk. As such, it is important that, as the new ODIs come into effect, the company takes steps to review and measure how well its risk mitigation plans are working. In our experience, this is much easier to do if prior thought is given as to: (i) how effectiveness can be monitored / measured; (ii) what metrics can be used to inform monitoring; and (ii) what practical steps are needed in order to ensure the necessary data can be recorded.

- **Where practical, Yorkshire should develop a framework and analytical evidence to better understand the drivers of outcome performance.** The company already has a good view as to how its actions impact likely ODI performance. However, we note that, in some cases, the drivers of ODI performance are complex and may include certain parameters that are (to some degree) outside of management control. We note, for example, that this has been an explicit consideration for Ofwat when making ODI determinations at PR14. As such, we similarly expect Ofwat to take this issue into account when making ODI determinations at PR19. Given this, it would be beneficial if the company developed its own framework for understanding ODI drivers, distinguishing between factors that are within / outside of management control, and to what degree. Where feasible, this framework could then be 'applied' using analysis (e.g. looking for relationships between drivers and performance over time, as data becomes available). Clearly, this will not be possible in many cases, and so a proportionate approach should be taken – focusing perhaps on the most material ODIs. However, we nonetheless consider developing a better understanding of drivers important for two reasons: (i) it will help the company better understand risk, and so better calibrate future ODIs; and (ii) it will ensure the company has high quality evidence when Ofwat makes ODI determinations at PR19.

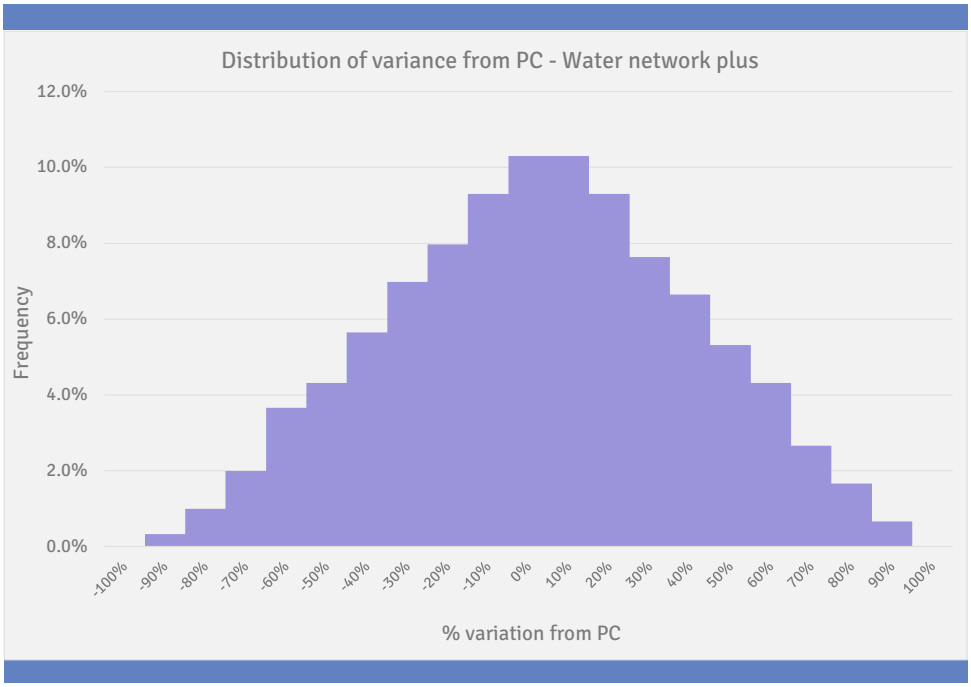
Annex – further details of probability distributions

This annex sets out the full range of probability distributions we estimated using historical data – including the 'low' and 'high' risk variants of our base distributions, as previously explained in the main body of our report.

4. Base case ODI performance risk (triangular) distributions

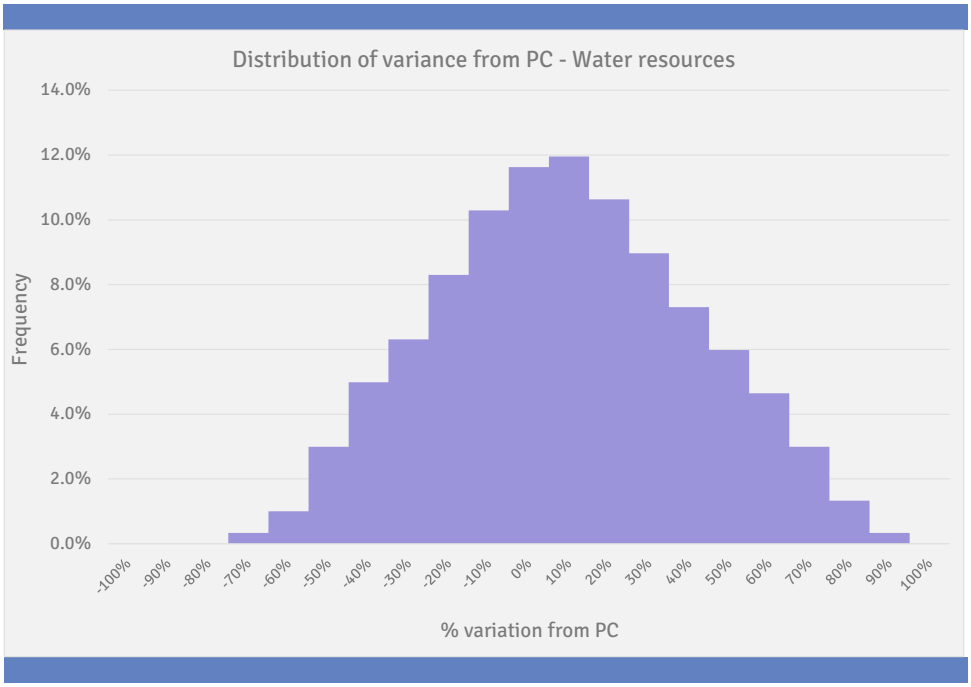
The following charts show out 'base case' estimated ODI performance risk distributions – estimated from the historical data.

Figure 28: Water network plus – base case triangular distribution



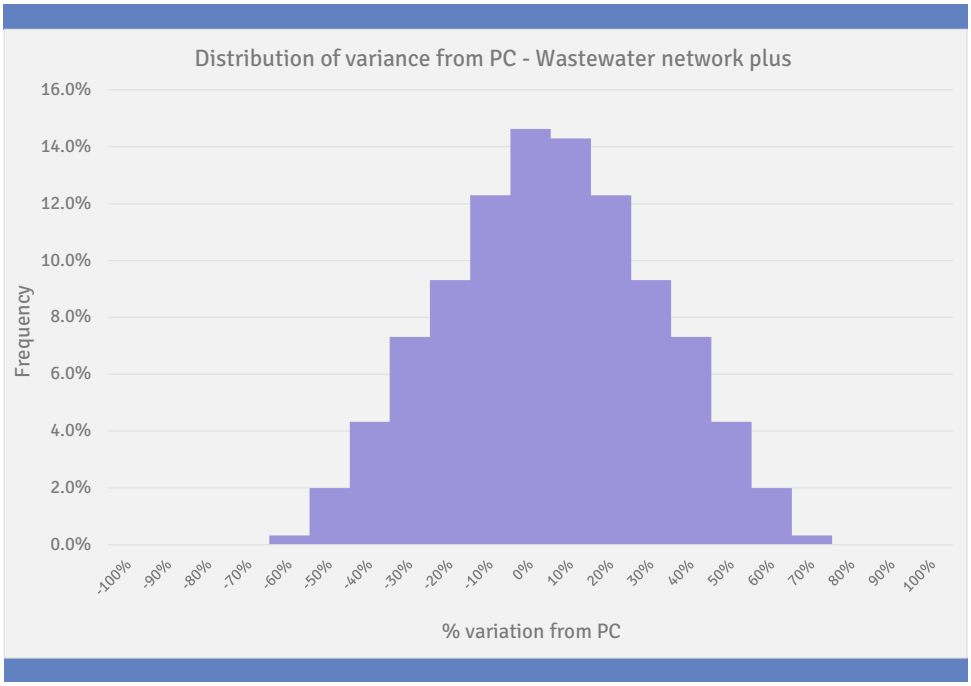
Source: Economic Insight

Figure 29: Water resources – base case triangular distribution



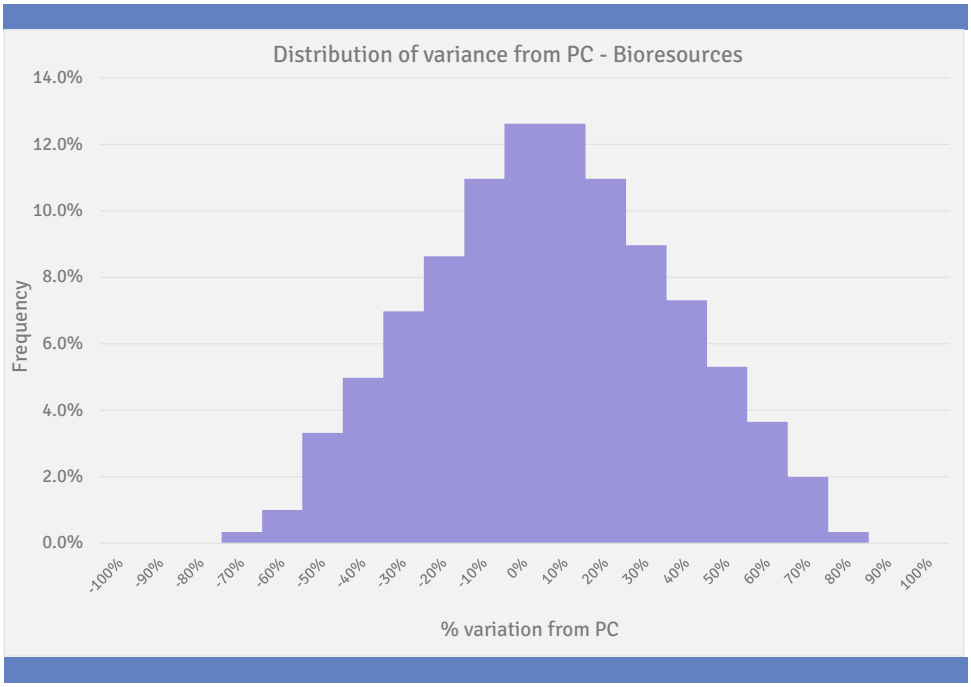
Source: Economic Insight

Figure 30: Wastewater network plus – base case triangular distribution



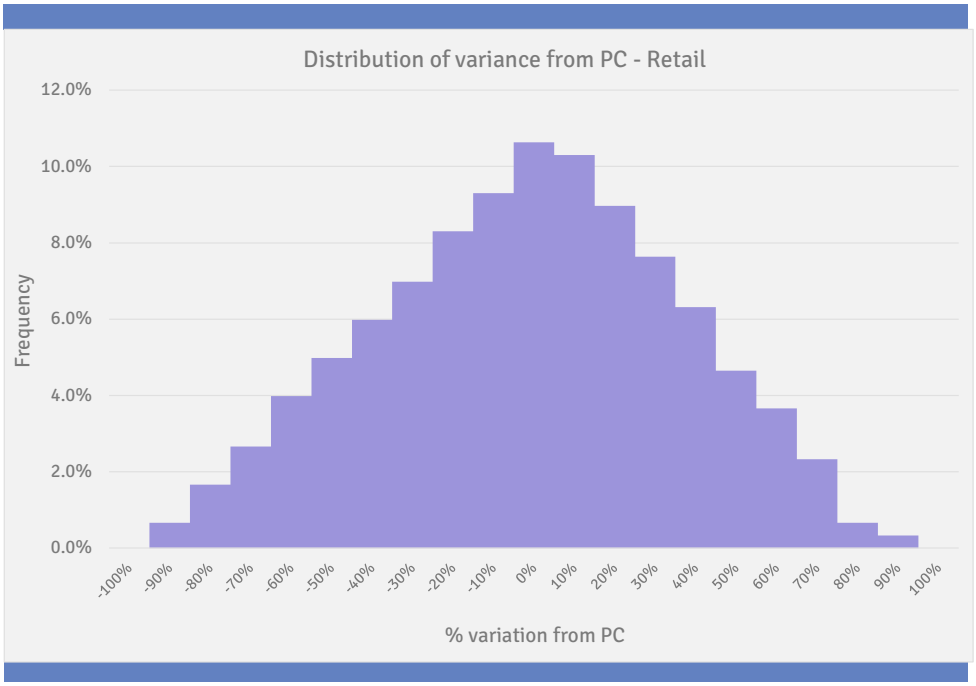
Source: Economic Insight

Figure 31: Bioresources – base case triangular distribution



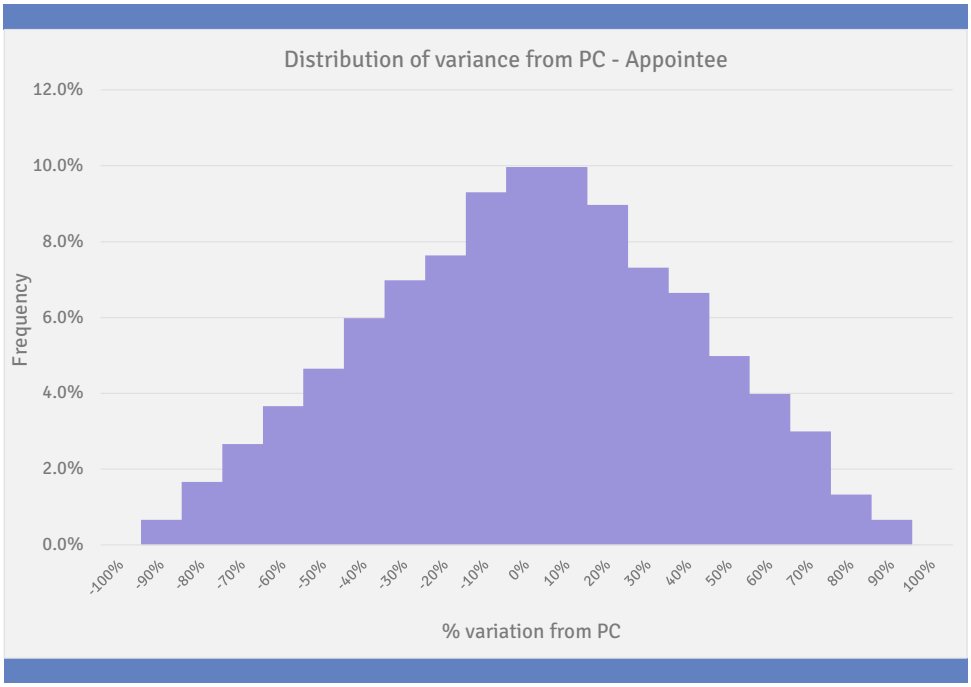
Source: Economic Insight

Figure 32: Retail – base case triangular distribution



Source: Economic Insight

Figure 33: Appointee – base case triangular distribution



Source: Economic Insight

6. Low risk' and 'high risk' variants

The following table show the key parameters used to derive the 'low' and 'high' risk variants of our estimated distributions, relative to the base case.

Table 6: Probability distribution parameters

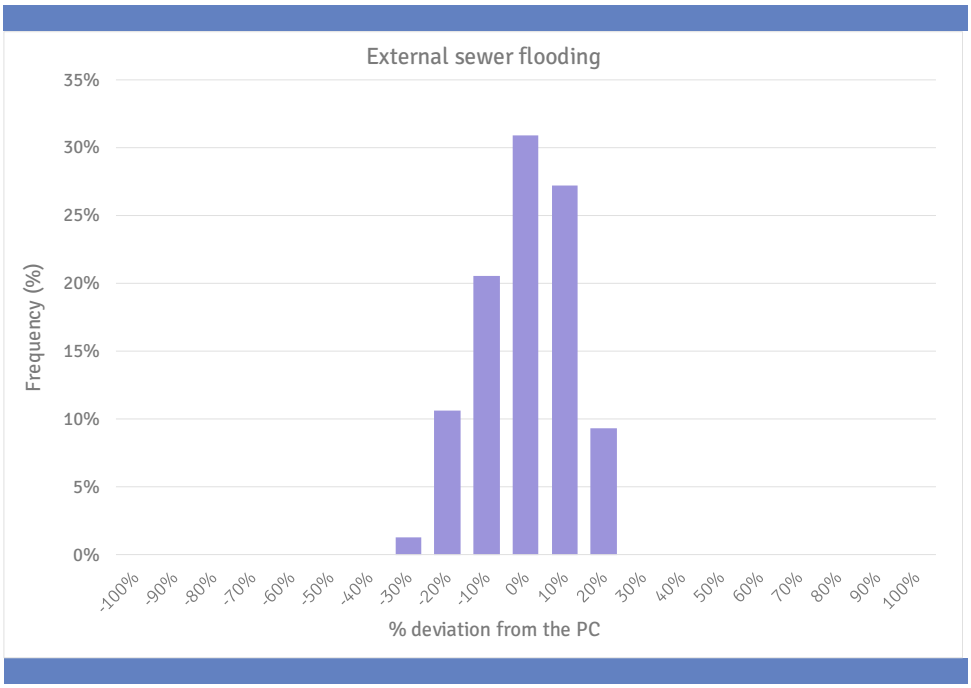
Control area	Probability distribution type	Min value (% of PC)	Max (% of PC)
Water network plus	High risk	-122%	115%
	Base case	-94%	88%
	Low risk	-66%	62%
Water resources	High risk	-94%	110%
	Base case	-72%	85%
	Low risk	-50%	59%
Wastewater network plus	High risk	-82%	82%
	Base case	-63%	63%
	Low risk	-44%	44%
Bioresources	High risk	-93%	98%
	Base case	-71%	75%
	Low risk	-50%	52%
Retail	High risk	-130%	106%
	Base case	-100%	82%
	Low risk	-70%	57%
Appointee	High risk	-130%	115%
	Base case	-100%	88%
	Low risk	-70%	62%

Source: Economic Insight

8. Distributions derived from Yorkshire expert views

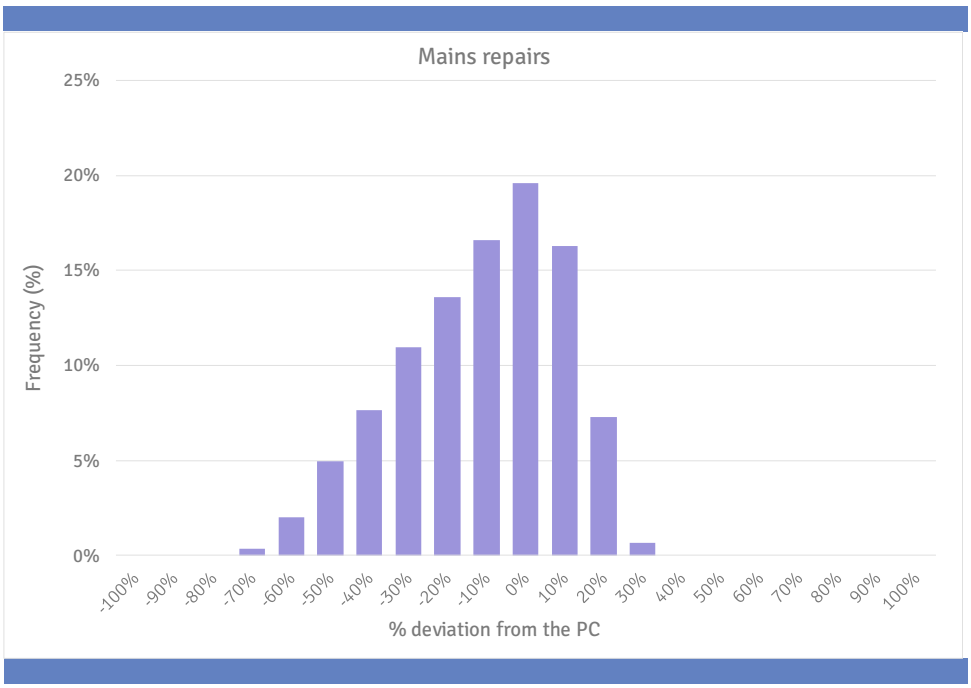
The following figures show the underlying distributions estimated from Yorkshire's expert views.

Figure 34: External sewer flooding



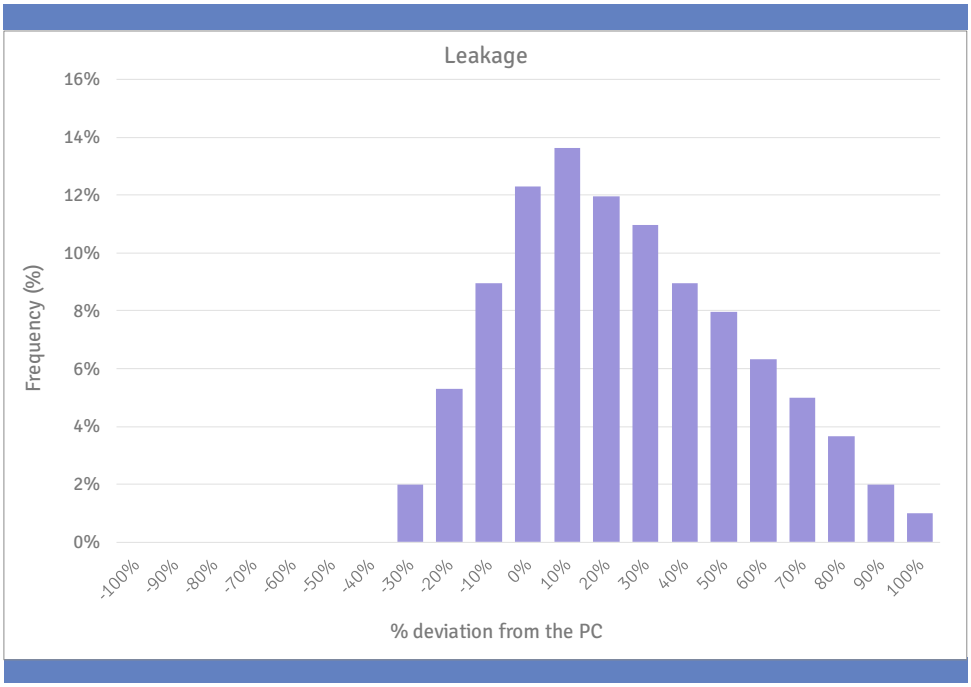
Source: Economic Insight

Figure 35: Mains repairs



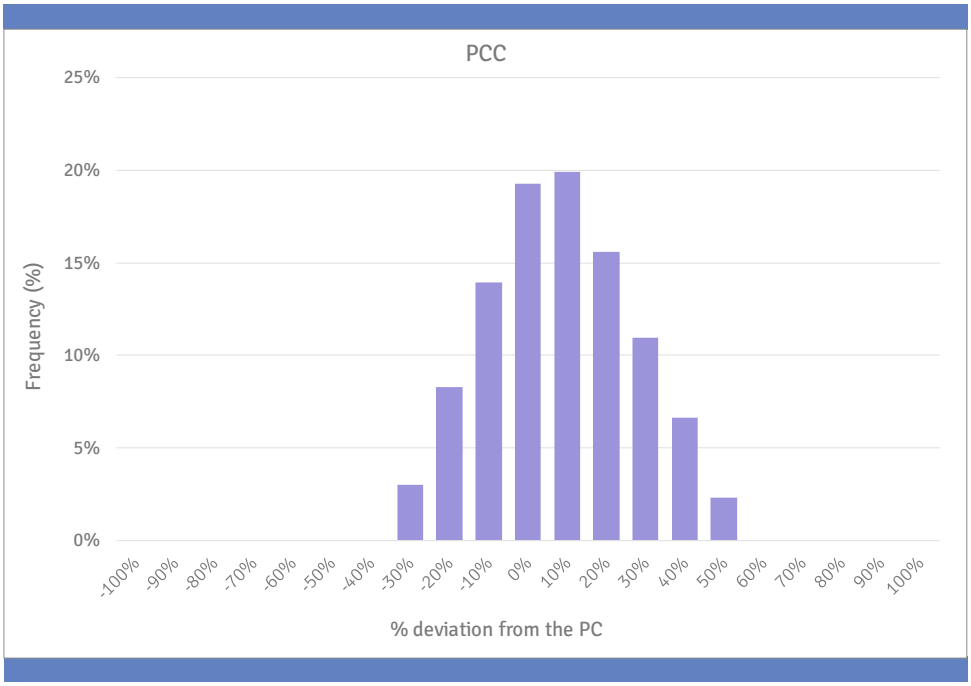
Source: Economic Insight

Figure 36: Leakage



Source: Economic Insight

Figure 37: Per capital consumption



Source: Economic Insight

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